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AND NATURAL GASOLINE MANUFACTURER

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GEORGE REID
Editor

CONTENTS

Special Features

Lobitos Applies Oil Circulation to Ultimate Yield Fractionation 140
J. A. Altshuler

Separator-Nobel Heavy Solvent Process of Dewaxing 147

Old Man Obsolescence 152
F. L. Kallam

Spent Doctor as a Research Problem 155
Kenneth S. Valentine and Gordon MacLean

Inspection of Oil Refinery Equipment—Part 2 158
F. L. Newcomb

Depreciation 163
L. C. Trescott

Technical Control of Percolation Filtration—Part 2 167
S. R. Funsten and H. L. King, Jr.

Alloyed Cast Irons in Petroleum Refining Equipment—Part 1 . . 171
J. S. Vanick

Combating Corrosion in California Refineries—Part 2 180
J. C. Albright

Kendall Makes Coking Run of 98 Days 185
F. J. Healy, C. H. Alberding and B. J. Flock

Design of Fractionating Columns—Article 2, Part 1 187
G. G. Brown, Mott Souders, Jr., H. V. Nyland and Wm. W. Heslar

Home Made Plug Valve Core Grinder 194

Testing and Repairing Orifice Meters 195
Russell M. Lilly

Regular Departments

The Look Box . . . . . 138 and 39a

Plant Activities 47a

Science and Technology (Abstracts) 54a

New Equipment for the Modern Plant 63a

Catalogs and Bulletins 69a

Advertisers' Index 70a

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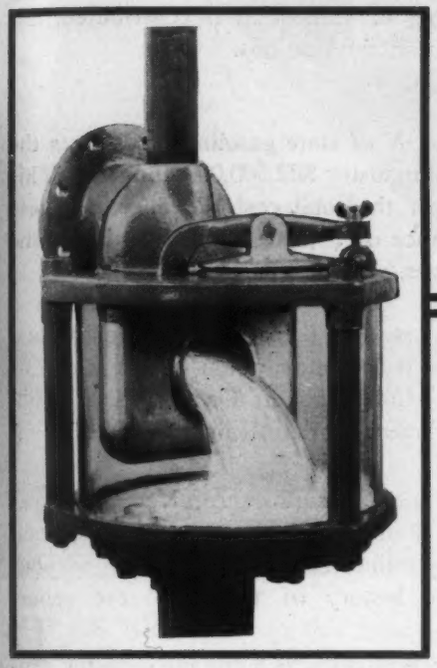


The Look Box

REFINERS should be interested in the present rumblings and rumors about a crude oil price increase. Any increase will certainly affect refinery operations.

Production And Prices

Conservatively, it is said, half of the current oil production of the United States is pumped from the wells, and this is a higher percentage, perhaps, than has prevailed at any time in the history of the industry. The added cost of pumping over natural flow is one of the penalties of the condition of having too much potential in the thousands of wells which are held in check by proration regulations. Prices of crude, however, are governed by the cheapness at which oil *could* be produced from the wells which are not allowed to flow. This circumstance reduces the operating profit of many pumping wells to the vanishing point. In fact, most of the small profit that comes from pumping wells is due to their cost having been absorbed in the profits made during their flush or flowing productive life. But many pumping wells were pumpers at completion, and still others fail to return even the cost of the lifting. Continued improvement in production control points to the possibility of higher prices for crude in the near future. That is the talk among producing organizations. They say further that conservation authorities who might be disposed to frown upon increased crude prices as being against the interest of the public at large, should consider the long period of meagre profits to the oil producer, if and when a crude price increase is indicated.

If it comes, the refiner with the most efficient facilities will be rewarded for the pains taken in bringing his equipment up to modern standards.

Gas Pipe Line

WHAT will be the result of the politicians' dream of a government-sponsored natural gas pipe line, from the Texas Panhandle to St. Louis and Detroit? There are some who fear the net result will be merely a temporary blocking of agitation for correcting the notorious gas waste situation in the big field.

The pipe line proposal appears to have diverted the drive for corrective legislation, or at least to have killed most of the vigor of the agitation. It is being predicted, consequently, that the operators who are stripping the gas and releasing it into the air will be able to continue operating without restraints for another year or two—while the pipe line project is being talked and talked.

It is but natural, under the circumstances, that the strippers are being suspected of encouraging the efforts and the talk in connection with the proposal.

The strippers know, it is argued, that the plan is not likely to be executed, despite the fact it sounds good on paper. For the lines that are already built and moving gas from the Panhandle to the Middle-West furnish doubt of the practicability of the plan, the existing lines having large amounts of unused capacity.

But the proposal looks interesting, nevertheless,

and it helps to detract attention from the notorious gas-wasting operations.

"Ideas"

A READER writes "The department of 'Ideas' beginning in THE REFINER for February (Page 53a) is a fine innovation. It should prove interesting and valuable to your readers. I hope you can keep it alive." To the writing reader—Thanks. But how much better it would have been if he had included two or more items for that "Ideas" page and helped to make it more interesting and more valuable. Some have contributed (and received their checks).

The "Ideas" page was omitted in the March issue because of lack of space. It appears again in this issue. The editors wish the readers would make this department theirs, contributing to it short items concerning anything which has proven of value to them in any of the various departments of the refinery or natural gasoline plant. It would also be a serviceable department for the asking and answering of questions concerning any thing of interest to the industry.

Examples: Some furnace oils may be treated in continuous treaters instead of in the agitators, cheaply and easily. How? Naphthas, kerosenes, furnace oils slightly moist may be dehydrated by passing them through some types of salt. How? Furnace tubes in some types of furnaces may be protected, their service life increased and the unit kept on stream for longer periods by metallizing certain tubes. How? A protective coating on blue prints, charts, plans, etc., undergoing frequent handling will preserve legibility. How? Illegible black figures and graduating marks on dials of pressure gauges can be restored easily. How? Worn shop floors can be refreshed by applying a mixture of emulsified asphalt and cement, extending their life. How?

The department of "Ideas" is open to all and will publish anything of value that is contributed, excepting, of course, duplications.

Tax Costs

COLLECTION of state gasoline taxes costs the petroleum industry $22,500,000 annually. This is 88 percent of the total cost of collecting these taxes, the balance of $3,000,000 being paid by the states themselves.

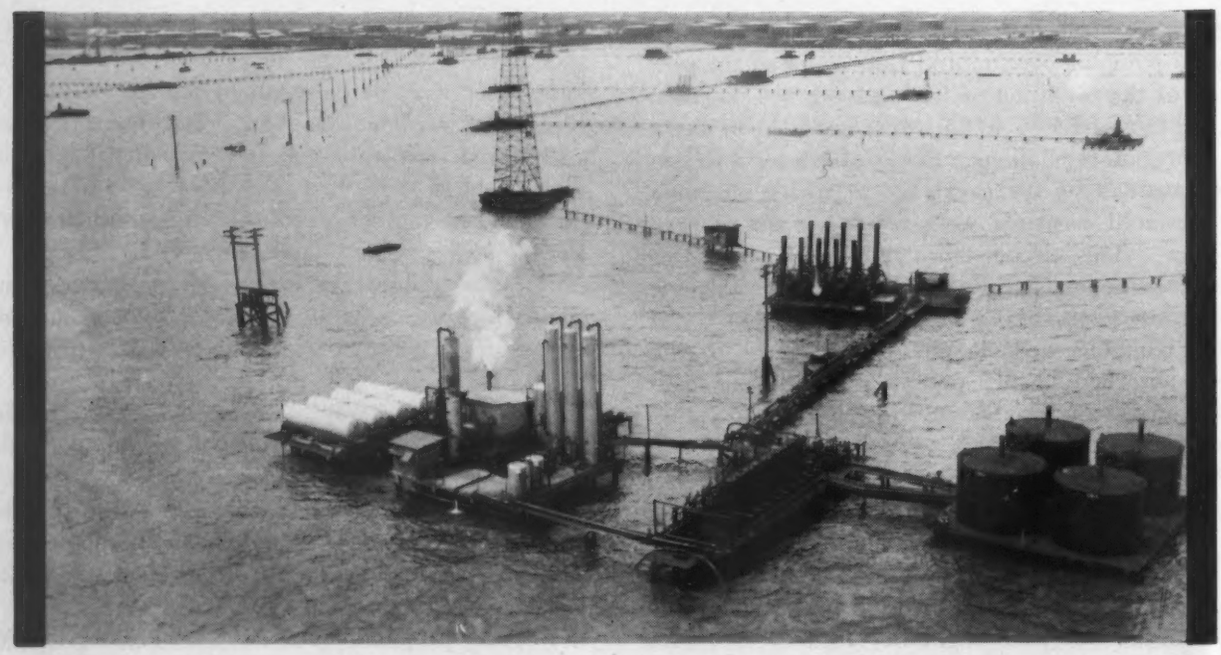
These estimates are made in a study of "The Petroleum Industry's Contribution to the Cost of Collecting the Gasoline Tax" published by the American Petroleum Industries Committee.

"The cooperation and assistance given by the petroleum industry in collecting taxes upon its principal product, gasoline, are unquestionably without parallel in the history of taxation," the report asserts.

Some of the services which the oil industry renders the tax collector are pointed out. A concern doing business on a national scale must employ legal talent to keep it informed with respect to the tax laws of the federal government, of 48 states and

(Continued on page 39a)

A view of Lake Maracaibo, Venezuela, where one of the world's outstanding marine drilling developments has taken place. Of particular interest in the accompanying photograph is the gasoline plant, which, like the derricks, has been constructed on pilings driven into the lake bed.



REFINING ENGINEERING PROGRESS 1935

Symposium—Part II

THE REFINER in this issue presents Part 2 of a symposium on Engineering Progress in Petroleum Refining, concluding the presentation of an important and valuable group of discussions which began in the March issue. This correlation of engineering and technical information has been made possible through the cooperation of several refining and engineering companies and manufacturing concerns. The articles present the latest available information of technical and engineering nature covering the various subjects discussed.

In the field of metallurgy the subject discussed here deals with the newly developed alloyed cast irons, their characteristics and their possible and probable uses in the refinery.

In the second article of the important and highly valuable series on Inspection of Refinery equipment, the author begins the discussion of "Methods of Conducting Inspections" and covers in detail the methods applicable to pressure and other cylindrical and spherical vessels, as well as the methods applicable to furnace tubes and header boxes. In this article the author gets well into the detailed instructions and constructive suggestions in regard to specific items and types of equipment.

Two articles are presented on depreciation and obsolescence which will prove of timely interest and value because of the nature of the times. Depreciated equipment and obsolete processes are deserving of the attention now being given them. Much of direct applicability is incorporated in the two discussions appearing in this issue.

The first detailed engineering and technical description of the trichlorethylene dewaxing process is presented this month and the discussion leaves little to be asked concerning the working and efficiencies of the process.

The newest refinery in England employed the oil recirculation system of distillation, and in this issue is presented a detail engineering discussion of the design, construction, and operating features of this plant.

A timely and interesting discussion of sodium plumbite solutions as sources of real revenue is presented under the title "Spent Doctor as a Research Problem."

The group of articles presented this month also includes the concluding part of the series of articles on combating corrosion in California refineries which was prepared through the cooperation of engineers and technologists with the leading California refining companies. The concluding chapter of the series on "Technical Control of Percolation Filtration" also is presented. Solvent refining processes have brought about new interest and activity in filtration work.

In compilation of this symposium each author has been given free rein in the complete covering of his subject and no attempt has been made to edit any author's personal opinion. The publishers of THE REFINER do not necessarily endorse any views so expressed; neither do they accept responsibility or liability for such views or expression of opinion.

Lobitos Applies Oil Circulation To Ultimate Yield Fractionation

THE Stratford Oil Circulation System of oil heating has been presented to the readers of The REFINER at various times over a period of the past several years, as a novel, efficient, economical, relatively inexpensive oil heating installation, when utilized as a heat source for various distilling units.

A recent description of the inside fired oil circulation heater and its application to modern fractionation equipment in the refinery of the Dacia Romana Petroleum Syndicate of Ploesti, Roumania, was presented by Stephan Dobrescu, in the July, 1933, issue of The REFINER.

IN the present article is disclosed the latest improvements in the system, and at the same time it is explained how the oil circulation system, when used as a heating means in a topping installation, has made possible yields and quality of products, flexibility and ease of operation, heretofore difficult in a continuous system. The latest installation was built for Lobitos Oilfields, Limited, at Ellesmere Port, near Chester, England, as a topping unit of a complete refinery, by Alco Products International of Paris, France, based on the designs of Stratford Engineering Company. The general refinery engineering was under the supervision of Harold Moore, consulting engineer, of London, England.

The Lobitos management desired to install a topping unit, specified to fulfill the following requirements:

1. Range of capacity from very low rates to 120 percent of rated capacity.
2. Flexibility of distillation range of products without upsetting the balance of the unit.
3. Maximum yields, i.e., gaps between products of not less than 9°F., so as to be assured of maximum recovery of those products for which there is greatest demand and highest price differential.
4. To provide a topped crude as the charge to an attached high vacuum lube unit, which would be free of light components.
5. To eliminate any detectable cracking in the topping stage.
6. To operate with a maximum thermal efficiency, and a minimum of operating personnel.

Naturally, such a distilling unit demands a heater, having rigidly fixed specifications. The requirements are in effect those of any efficient modern heating means, and are briefly as follows:

1. To provide a means of efficiently elevating the charge to distilling temperature, vaporizing the desired percentage, and in addition to make available a practically unlimited supply of circulating oil at high temperature level. This circulating oil can be used as a counter-current indirect heating medium in the preheating of the charge to any individual fractionating tower, and for the indispensable and variable supply of reboiler heat to the bases of the towers, which makes ultimate yield fractionation possible.
2. To maintain a low film temperature, which at all times is below the decomposition temperature of the oil undergoing heating.
3. To maintain a clean, carbon-free, heating surface in order not to impair heat transfer efficiency since reduced heat transfer efficiency also means short service factor and frequent cleaning.
4. To make possible high radiant heat transfer rates, in order to reduce the area of heating surface required, thus reducing the capital investment.

The first requisite of high radiant heat transfer rates is, of course, high flame burst temperature, which requires efficient combustion. The second requirement is that of maintaining a flow of oil over the heated surface at sufficient velocity and of sufficient volume to maintain remarkably low film temperatures, and fulfill the requirements of one to four above. With these fundamentals of oil heating as an objective, a means of fulfillment was necessary of solution, which was practical from the fabrication and operation viewpoint, and reasonable in initial cost.

The inside fired oil circulation heater was chosen as being suited for the work in hand. Its design is simple and is based on years of experimental work and commercial operations. The fundamentals are as follows:

As is generally known, hydraulic research has shown that a high velocity liquid jet, when directed against a flat plate will change direction with a very low loss of velocity (approximately three percent). The liquid discharge from such a nozzle, after striking the plate, forms a high velocity film or sheet flow of liquid passing over the plate surface, radially from the area of im-

*Vice President Stratford Engineering Corp., formerly technical director Alco Products International, Paris, France.

PETROLEUM ENGINEERING PROGRESS 1935

J. A. ALTSHULER*

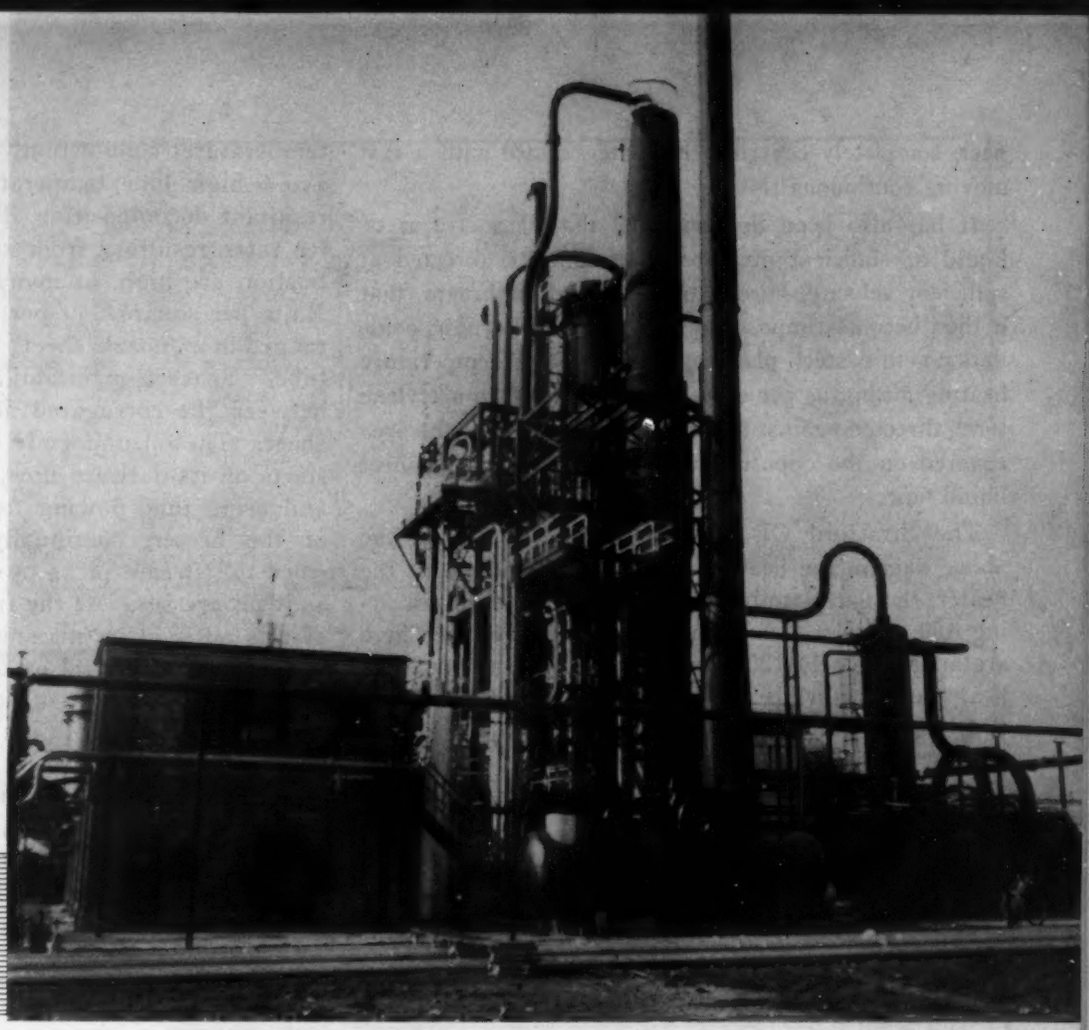


FIGURE 1
Lobitos Installation

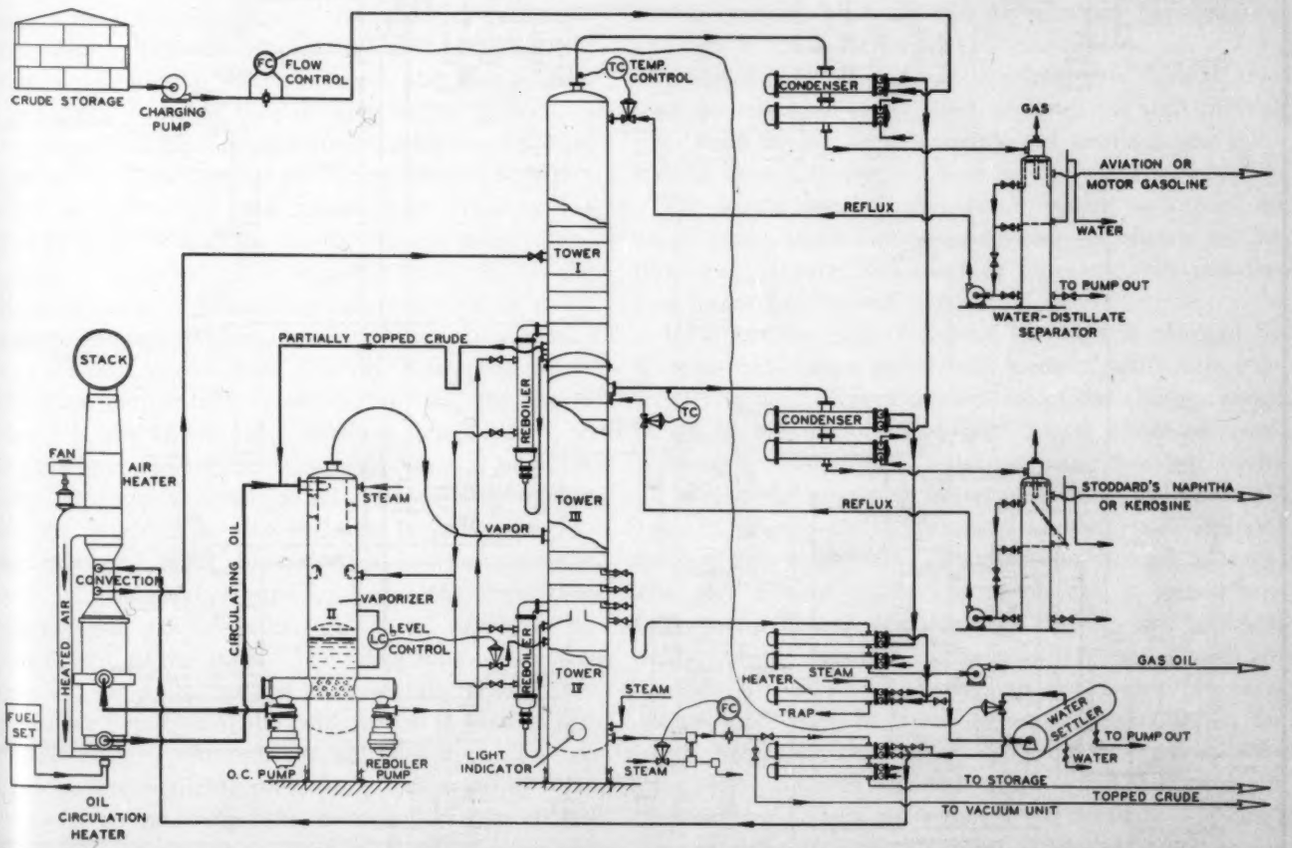


FIGURE 2
Flow Chart, Lobitos Topping Unit.

pact, completely covering the plate surface with a fast moving continuous flow.

It has also been demonstrated that if a stream of liquid of sufficient mass per unit time, be directed at sufficient velocity, normal to a heating diaphragm, that it then becomes impossible to destroy by burning (oxidation) this steel plate by normal high temperature heating means, as per extreme example, by an acetylene torch directed against the transfer surface over the area covered on the opposite side by a high velocity sheet liquid flow.

The Stratford Oil Circulation System utilizes the above data in the heating of oil. In the design of the heater, the flat plate becomes a circular corrugated firing tube, four feet in diameter by 12 feet long. There are approximately 120 square feet of effective radiant heat transfer surface. The nozzles are so arranged as to cover the entire fired surface with jets of oil, leaving the nozzles at 90-100 feet per second, and discharging against the fired sheet, thus providing an unbroken, rapidly moving and continuous flow of oil over the heated surface. The nozzles are spaced at such intervals that a sufficient volume (mass) of oil is passing over the sheet at all times to absorb the heat from high temperature combustion, and still avoid high film temperatures and resultant decomposition. The transfer rates resulting from such combustion are high, in many cases, well over 100,000 B.t.u. per square foot per hour. The nozzles are arranged in a "nozzle sheet" which is a concentric steel tube. Spacers maintain a uniform short distance between the corrugated firing tube, and the nozzle sheet. The oil uniformly discharged by the nozzles starts on its outward flow, between the nozzle sheet and firing tube flowing from the back to the front of the heater, continually increasing in velocity, since the stream picks up the flow from all nozzles as it progresses. At the front or fired end the mass of this oil is at its maximum, as is required by the high temperature level of the fired end of the heater, and the large quantity of heat to be absorbed.

An annular header at the front of the heater around its circumference, collects the heated oil which then flows under circulating pump pressure to the vaporizer —Tower No. 2 (to be later described). The heater is always under low pressure, operates liquid full and no vaporization occurs therein.

Circulating oil is supplied to the heater by a single

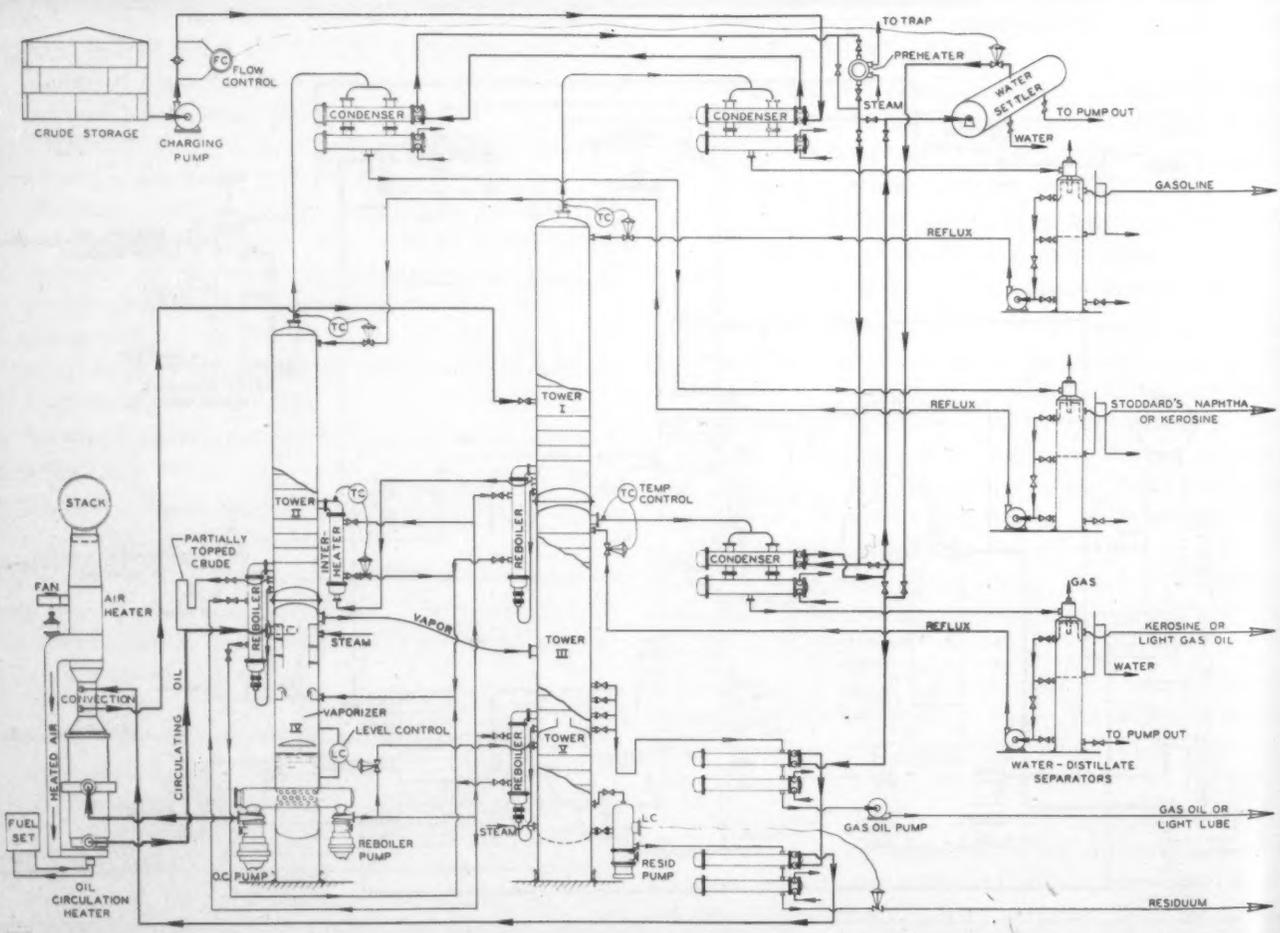


FIGURE 3

Flow Chart—Oil circulation system when four gapped products are required.

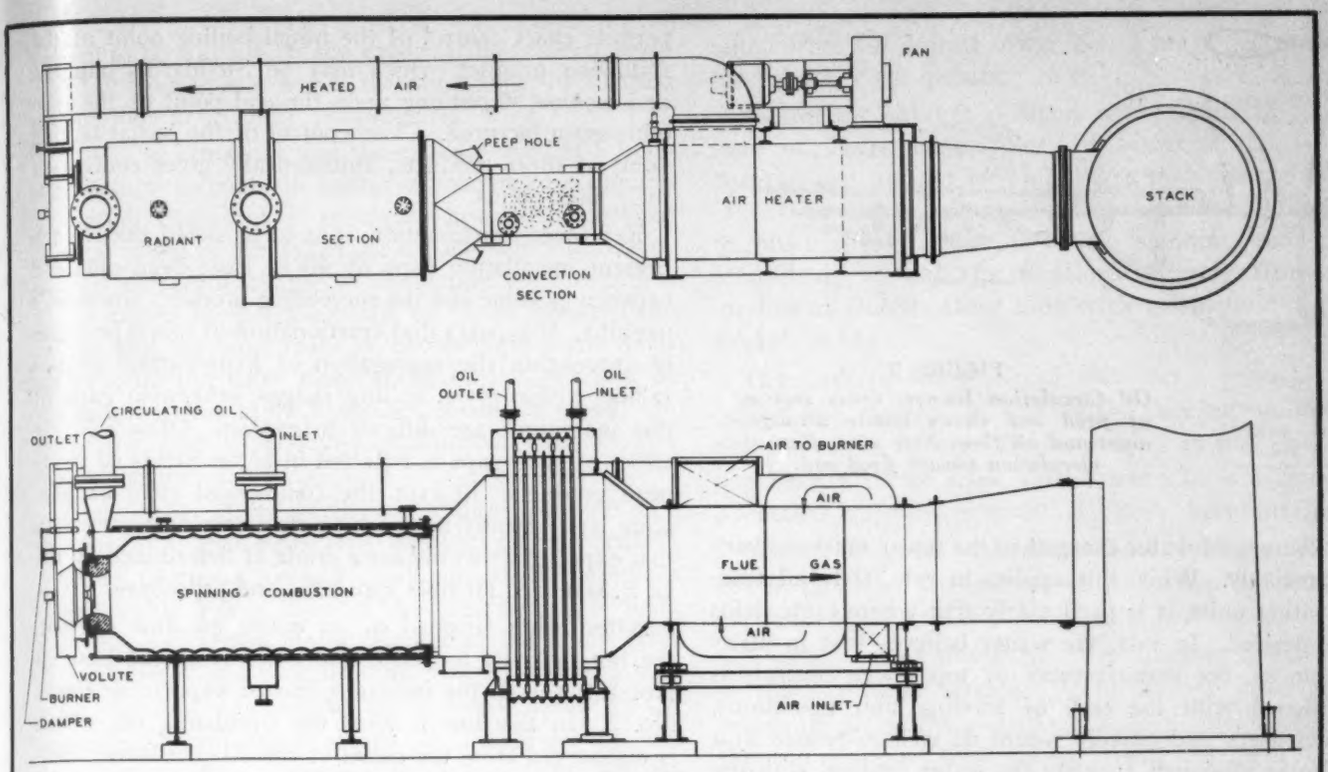


FIGURE 4

Oil circulation heater assembly showing convection section and air heater.

stage, vertical centrifugal pump, which takes suction from the base of the vaporizing tower No. 2, and discharges into a circular header, roundabout the center of the heater. The oil is uniformly distributed to the nozzles in an annular space between the nozzle sheet and an outer concentric tube or shell of the heater.

The specialized high temperature combustion required is supplied by a mechanical atomizing burner, to which heated fuel is supplied by a quimby high pressure fuel pump. In order to elevate the flameburst temperature, heated air is required. It is supplied by a cold air fan discharging under a pressure of several inches of water, through a corrugated plate, envelope type, air preheater counter current to flue gas. The air is supplied to the burner at a temperature of 600-650°F. and the flow is regulated at the burner by a sensitive damper.

The flue gas leaving the firing tube flows at turbulent velocity through a small, tubular convection section, where the crude charge to the unit is preheated, and where the total heat absorption is approximately 10 percent of the total required. From the convection section the flue gas flows through the air preheater described above, to the stack. The firing tube, convection section and air preheater are always under stack draft. The positive pressure of the cold air fan is used to provide high velocity through the air preheater. The remainder of the available pressure is converted to rotating velocity in the firing tube, by being introduced into the tube through a volute. Spinning combustion at high R.P.M. assures satisfactory fuel-air mixing and high convection transfer rates in the radiant section.

Fuel oil and air are introduced into the firing tube through a firing "Venturi" or masonry burner throat. This is the only masonry in the entire installation, eliminating residual heat, as well as masonry maintenance and repair.

When the fire is put out, the heater is "dead." No long recirculation is required to bring the unit off the line, same having been accomplished within a few minutes in actual refinery operations.

The inside fired oil circulation heater as applied to an ultimate yield fractionating unit, is shown in the flow sheet Figure No. 2, which represents the installation in the Lobitos refinery.

Its operation is as follows: The unit is charged by a centrifugal pump under conditions of automatic control. The need of accurate control of the charge cannot be too strongly emphasized, particularly where extremely close fractionation is required, since flow variations of any great magnitude upset materially the heat balance of the towers. Maximum product yields demand floating unit conditions. After passing through heat exchangers against product streams, and a steam preheater, the heated crude passes through a horizontal settler of the decelerating type, where water and impurities are removed by settling hot under pressure. While there may be traces of water remaining in the crude after leaving the settler, there is no possibility of greatly variable quantities of water entering the fractionator. Slugs of water, with resultant "puking" are unknown where this type of settler is employed, even though the crude contains variable quantities of water up to 20 percent by volume of the charge.

In order to maintain "floating" unit conditions the

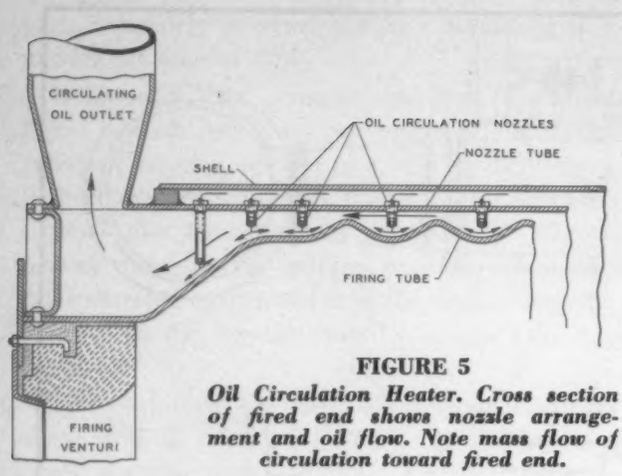


FIGURE 5

Oil Circulation Heater. Cross section of fired end shows nozzle arrangement and oil flow. Note mass flow of circulation toward fired end.

percentage of water charged to the tower must not vary appreciably. While this applies in general to all fractionating units, it is particularly true where high yields are desired. In fact, the writer believes that in many instances, the manufacturer of top tower controls is burdened with the task of leveling unit operations, when users undoubtedly would do well to reduce to a uniform minimum quantity the water charged with the crude to the first fractionator.

The steam preheater is installed to make possible charging the unit (when starting) with hot crude, and to preclude the possibility of charging variable quantities of water. The settler operates hot and liquid-full under pressure, such pressure being maintained by the flow control valve, located at the settler outlet. Being under pressure, formation of vapor, which disturbs settling, is impossible.

From the settler the crude passes through the tubular convection section of the heater, where it is partially vaporized, and through which it flows at high velocity. It is interesting to note that the tubes of the convection section rarely, if ever, require cleaning. The mixed oil and vapor are discharged, still under crude charging pump pressure, to fractionating tower No. 1, the gasoline tower, from the top of which gasoline is taken in the vapor phase. This gasoline may be varied at will from a very light product of aviation boiling range, 285°F.-300°F.; end point to a normal motor spirit having an end point of 390-410°F. Sensitive end point control, easy of regulation and change is required, and for this purpose electric anticipatory type pyrometer controls are used. The instruments operate within extremely narrow limits, as required for close fractionation. End point change in the product requires only a change of instrument dial setting and changes are reflected very rapidly.

A maximum yield of closely fractionated gasoline is assured by sufficient rectifying plates above the point of injection of the hot crude to the tower. The last traces of overhead product are extracted by the stripping plates below the point of injection, and by the heat supplied by a tubular thermo-syphon circulation reboiler. The combination of stripping plates and reboiler permits exact control of the initial boiling point of the following product, which may be Stoddard's naphtha or kerosene, depending upon the end point of the gasoline manufactured. Close control of the initial boiling point of these products, automatically gives control of their flash points.

Reference fractionation, it is to be noted that in the present installation gaps of 40°F. have been obtained between gasoline and the succeeding product, Stoddard's naphtha. It appears that fractionation of this type closely approaches the segregation of hydrocarbon groups falling within given boiling ranges, otherwise gaps of this magnitude are difficult to explain. Obviously the effect of such gaps is reflected in better yields of overhead products. In fact, the commercial yield of gasoline is frequently as much as six percent greater than that expected from the same crude as determined by the U. S. standard Hempel apparatus and procedure.

After being stripped of its entire gasoline content, the hot partially topped crude flows from the base of No. 1 tower to the injection line of vaporizing tower No. 2. In this line it joins the circulating oil, which is discharged from the outlet of the oil circulation heater. The quantity of circulating oil is many times that of the crude, and in the case of this installation, it is approximately 50 to one. This mass of oil is used as a heat vehicle for the elevation of the topped crude from tower No. 1 to vaporizing equilibrium temperature.

Since the ratio of the quantity of the oil circulated to the crude charge is so great, the temperature rise in the heater is very low, rarely, if ever, exceeding 10°F. The circulation oil mixed with the partially topped crude elevated to vaporizing temperature and containing the vapor flashed at this temperature, are mixed in the injection line to vaporizing tower No. 2, and are introduced into the centrifugal vaporizing head in the top of the tower. The cleanly separated vapors are injected under the rectifying plates, and over the stripping plates of fractionating tower No. 3.

This circulating oil, plus the part of the crude not vaporized, flows to the base of the vaporizer, which serves as a reservoir for the oil heating system. From the base of the vaporizer, one special single stage centrifugal vertical pump, having a capacity of approximately 3000 gallons per minute, discharges to the heater.

A second pump of the same design, also using the base of the vaporizer as its reservoir, supplies the heating oil required to the various reboilers of the unit, and discharges the excess unstripped residuum to a stripping tower No. 4. The quantity of unstripped residuum thus discharged, is regulated by a differential level controller on the vaporizer.

The oil used as a heating medium for the reboilers is returned to the vaporizer, where it joins the mass of circulating oil, and where it is instantaneously brought back to the temperature of the main oil body by oil to oil contact. The quantity circulated through the reboiler

system in no way affects the vaporizer liquid level, since oil so utilized is returned to the same tower in a closed circuit, but at a lower temperature.

It is to be remarked that the material used as a heating medium through the heater is unstripped residuum. The crude charge never enters the heater except when the unit is put on and taken off the line. Since the elevation of the crude charge to distillation temperature is accomplished by direct contact, oil to oil, between the charge and the large mass of circulating oil, and since all vaporization takes place ahead of the injection of the mixed stream to the vaporizer, conditions closely approaching true vapor-liquid equilibrium exist in this flash chamber.

Since the conditions in vaporizing tower No. 2 so closely approximate true equilibrium, it becomes possible to top a normal crude oil at temperatures considerably lower than in the case of single flash systems, where the major portion of the latent heat is supplied by elevating the temperature of the total stream. When using a small quantity of superheated injection steam in the head of the vaporizing tower, a normal crude has been reduced to a 45 percent residuum at a maximum temperature of 480° F.

The possibility of distilling at lower temperatures becomes useful, in cases where bottom corrosion exists at the normal operating temperatures of single flash systems.

Since the quantity of material circulated through the heater is constant, and since the partially topped crude is introduced into the heated stream of circulating oil en route to the vaporizer, the operation of the system is completely independent of crude charging rate. Because of this fact, the user has a machine in the refinery sufficiently flexible to meet any distillation requirements, reference charging rates and degree of fractionation.

The vapor mixture from the centrifugal separating head of the vaporizer is introduced under the rectifying plates and above the stripping plates of tower No. 3. This tower is used for the manufacture of white spirit (Stoddard's naphtha) of 390-410° F. end point when a gasoline of aviation boiling range is being manufactured in tower No. 1, or alternately kerosene of 520-575° F. end point when motor gasoline is being manufactured. The top of tower No. 3 is equipped with the same type of temperature control apparatus, as described previously for tower No. 1.

The flash point of either white spirit (Stoddard's naphtha) or kerosene is easily controlled if desired by the reboiler control on the gasoline tower No. 1. Assuming that considerable gap exists between the end point of the gasoline, and the initial boiling point of the following product, then the distillates taken from the top of tower No. 3 must necessarily have high flash points.

Should the market demand white spirit or kerosene of lower flash point, or lower initial, such demand can be met by blending a small percentage of the preceding product. It is more economical to meet specifications by such blending than by attempting to cut the fractions directly from an inefficient fractionating unit with subsequent sacrifice of yields.

The base of tower No. 3 also has a vertical reboiler and control of the initial boiling point of the gas oil is affected by its use, as is the yield of overhead product from this tower. In commercial operation gaps of over 30° F. have been attained.

Gas oil may be withdrawn from the base of the tower or from the plates of its stripping section as desired.

The bottom of tower No. 3 refluxes to tower No. 4, the residuum stripper. The excess unstripped residuum from the vaporizer is also introduced on the top plate of this tower, where the light components are vaporized by counter flow against superheated steam. These rising vapors also serve as further reboiling means for the base of tower No. 3.

The stripped residuum is withdrawn as the charge to an attached vacuum unit, or optionally can be cooled and pumped to storage.

By means of a combination of the reboiler, still

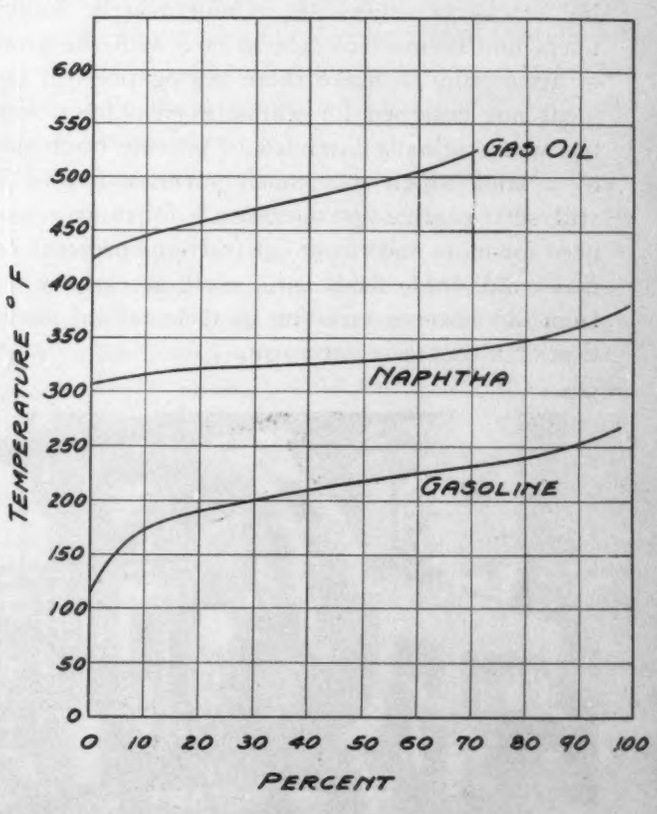


FIGURE 7

Typical distillation curves showing gaps between products.

temperature, superheated injection steam, and the place of withdrawal, it becomes possible to control, within commercial requirements, the end point of the gas oil and the initial boiling point of the charge to the vacuum unit. However, if a greater yield of light spindle oil 100 SSU at 70° F. is desired then one additional fractionating tower becomes necessary. The recommended system for this case is shown in flow sheet, figure 3, wherein it will be noted that gas oil may be taken overhead in the vapor phase. When so doing, it becomes possible to gap considerably the light spindle from the gas oil and with such an installation the refiner is assured that maximum yield of spindle oil is separated from the gas oil. If still narrower boiling range is desired, or if it becomes advisable to segregate where possible, hydrocarbon groups for purposes of isolating valuable components for use as blending stocks, by reason of their octane number or for by-product of chemical manufacture; same may be accomplished in the type of installation shown in Figure 3.

In fact, the fractionation of petroleum hydrocarbons has reached the point today where the refiner has only to state his requirements and furnish a sample of his charging stock. From there on, recent practice has shown the way for maximum extraction and segregation of special close-cut fractions.

It is the writer's opinion that the trend of the industry is toward closer fractionation and segregation of the various components for use as blending stocks or otherwise. Unfortunately many refiners find themselves face to face with the problem of attempting to make these segregations in equipment not designed for ultimate yield fractionation, but was originally intended to provide fractionation of a kind which was much superior to old shell still semi-continuous operation. Obviously as the need for more and closer cut fractions presents itself, many old single flash units must necessarily suffer from obsolescence resulting in their radical modification or ultimate replacement.

In order to provide the flexibility and closeness of fractionation required, the Lobitos installation would tend to show the practicability of multi-tower installations, each tower to be reboiler equipped. Since these reboilers require large quantities of heat, the heating problem for large masses of reboiling medium becomes complex in the conventional pipe still.

In addition to its application to ultimate yield fractionation it may prove of interest to point out some of the other possible applications of oil circulation. They are as follows:

1. For the heating required in the separation of solvent materials from extract and raffinate of modern solvent treating processes, where two or more separate pipe stills are now required. One oil circulation system replaces multiple pipe stills at greatly reduced initial investment, and provides increased flexibility and ease of operation.
2. In two or three stage pressure distillate rerun plants operating under high vacuum on the latter stages where maximum temperature of 260/300° F. must not be exceeded.
3. For the heating of lubricating oil distillates containing small quantities of finely divided clay to the optimum reaction temperature. In this case, the heating would be by indirect equipment designed to withstand erosion, thus eliminating frequent replacements of the tubes so common where tubular heaters are utilized for this service.
4. In grease manufacturing plants where heating means are required, and where high pressure steam is not available.
5. Reboiling by indirect heating in absorption plants particularly in remote locations when high pressure steam generating plants are not available, or expensive to install.
6. For the heating of lubricating oil distillates to dehydration temperature previous to chemical treatment.

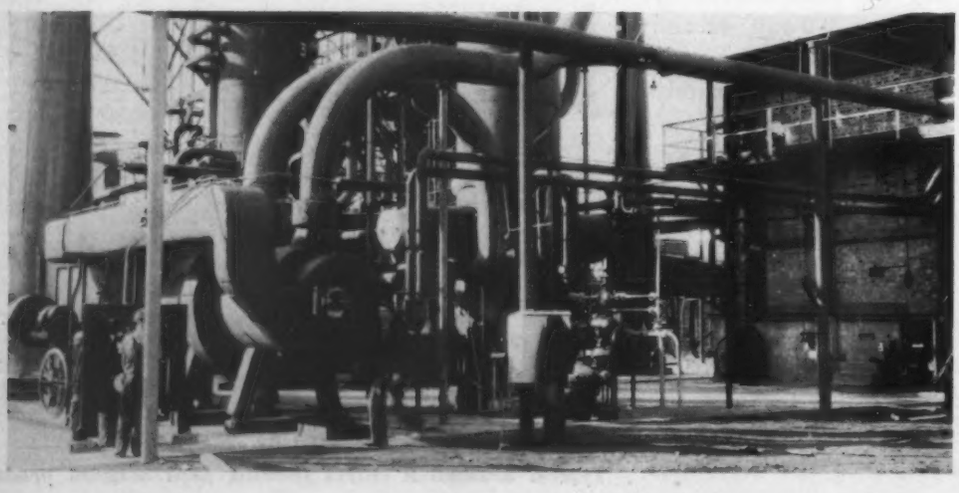


FIGURE 6

Stratford oil circulation heater, showing circulating pump, oil circulating lines and heated air volute.

Separator-Nobel *Heavy Solvent* Process of Dewaxing

IN the September, 1934, issue of The Refiner, a brief description of the Separator-Nobel Dewaxing Process was published (Vol. 13, No. 9, Page 41a). This dealt with the plant as installed at the Standard Franco-Americaine de Raffinage refinery in Port-Jerome, France. Operating data showing satisfactory results obtained there in regard to pour and cloud point, economy of chilling and the like, but as to the process itself very little information was included. Through the courtesy of Aktiebolaget Separator-Nobel, Stockholm, Sweden, the accompanying detailed discussion of the process was prepared exclusively for The Refiner.

REFINING ENGINEERING PROGRESS 1935

THE Separator-Nobel dewaxing process is principally characterized by the use of chlorinated hydrocarbons as solvent and by the special design of the centrifuge used for removing the precipitated wax.

Besides being excellent dewaxing solvents from an oil-dissolving and wax-precipitating point of view, the chlorinated hydrocarbons in question (trichlorethylene, carbontetrachloride, methylenchloride, dichlorethane, etc.) have a high specific gravity and low boiling point. Moreover, they are non-inflammable, whereby fire hazard is eliminated.

High specific gravity of the solvent means low dilution required to obtain the necessary difference in specific gravity between the oil-solvent blend and the wax to be centrifuged out. Low dilution results in low first, and operating costs at the chilling plant.

Since the oil-solvent solution is heavier than the wax, the latter "floats" on the liquid in the centrifugal bowl, whereby the continuous discharge of the semi-solid wax from the bowl is rendered easy and independent of the nature of the wax.

Another advantage of the high specific gravity of the solvent is the fact that it can be stored under a water blanket, since it is immiscible with water. Evaporation losses during storage are thus eliminated in a simple and cheap manner.

Low boiling point and low specific and latent heat render the distillation of the solvent from the separated oil and wax an easy and inexpensive operation.

Of the many chlorinated hydrocarbons tried by the Separator Nobel Company when developing this process, trichlorethylene (C_2HCl_3) has proved suitable for most kinds of oil. Its principle physical properties are shown below:

Specific gravity at 60°F	1.476
Boiling point	188°F.
Specific heat	0.23 B.t.u./lb. and °F.
Latent heat	101 B.t.u./lb.
Solubility of water in tri at 50°F	0.017 percent by wt.

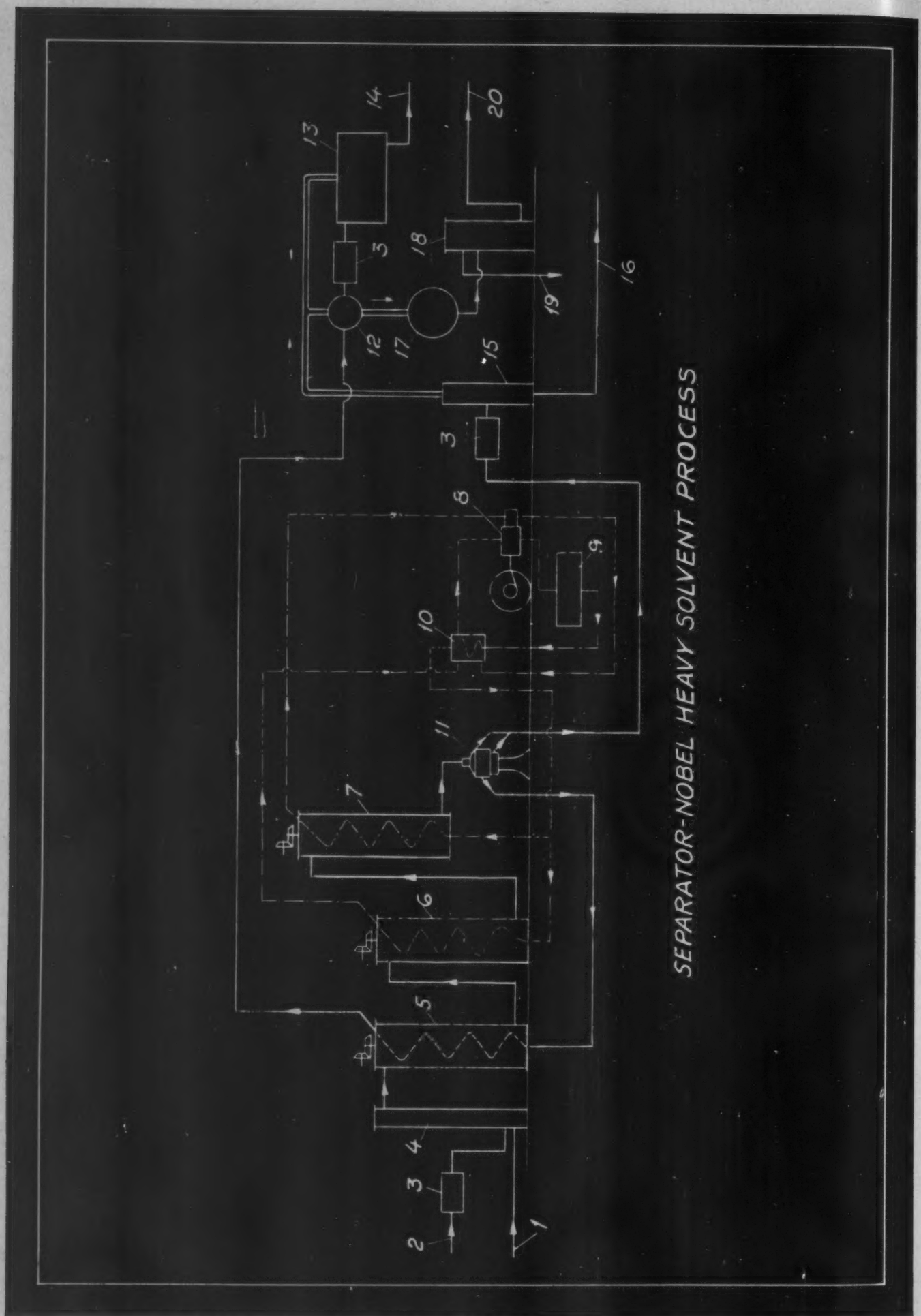
Trichlorethylene dissolves asphaltic bodies present in the oil, transferring them into a non-inhibitor state so that even asphaltic residues can to advantage be dewaxed without previous detarring, and a wide range of mixed base crudes can be used to manufacture lubricating oils. It is non-corrosive, it does neither hydrolize nor decompose on heating up to about 265°F. When distilling with steam at below 265°F., there is no danger of corrosion of the material of construction.

The dewaxing centrifuge differs considerably from the usual type of centrifuges as far as design of bowl and receptacles is concerned.

The semi-solid wax is automatically and continuously discharged from the central part of the bowl into a steam heated wax receptacle, whereas the dewaxed cold oil solution is discharged into a carefully heat-insulated receptacle in view of the fact that this solution is generally used for pre-cooling the fresh oil-solvent blend to be centrifuged.

The centrifuge is completely vapor-tight and provided with sight control glasses at inlets and outlets. It has a capacity of 50 to 120 barrels of oil per 24 hours, depending on the wax content and viscosity of the lubricating stock.

Besides the centrifuges the dewaxing plant comprises apparatus for blending oil and solvent, refrigerating plant and chillers (crystallizers) and distilling plant for recovering the solvent. The plant can be designed for continuous or intermittent treat-


SEPARATOR-NOBEL HEAVY SOLVENT PROCESS
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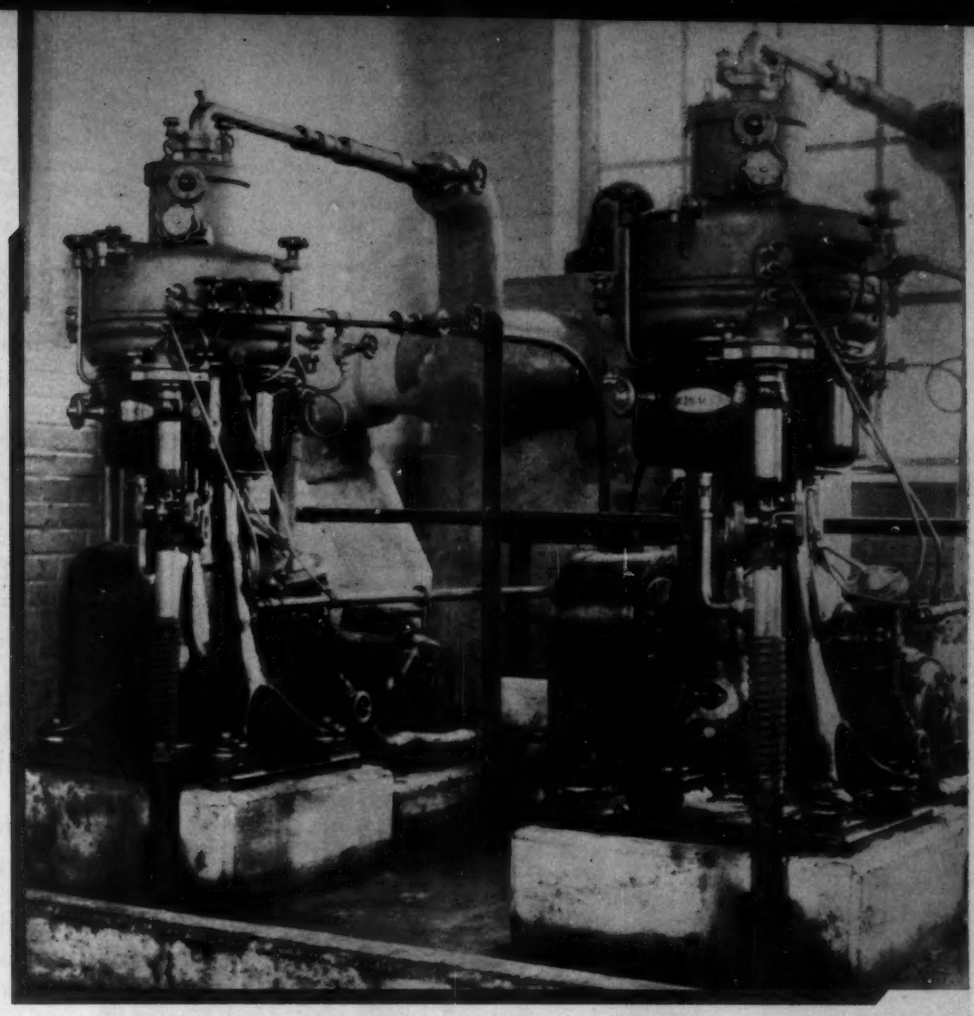


S-N Dewaxing Centrifuges installed in a European refinery.

ment, as desired. Continuous chilling, however, means lower plant and refrigerating costs, less solvent required on hand, simpler operation, etc., and is thus preferable to batch chilling. The diagram shows schematically a complete S-N dewaxing plant for continuous operation.

The oil is heated to an appropriate temperature for blending, which takes place in the mixing column 4 at about 100-120°F., depending on the characteristics of the oil. From the mixing column the oil passes into a vertical cooler 5, where it is pre-cooled by the cold solution discharged from the centrifuges 11. The chillers 6 and 7 are equipped with agitators in the top and work with direct expansion of ammonia from the refrigerating plant 8-10. From the chiller 7 the solution flows into the centrifuges 11 at the desired separating temperature, which is normally about minus 20°F.

The dewaxed solution, after passing through the pre-cooler 5, is pre-heated in 12 by means of overhead solvent vapors from the stills and is then passed through steam pre-heater 3 into the still 13, where it is heated to about 230°F. by indirect exhaust steam, the last traces of solvent being finally driven off by means of live steam. The solvent-free oil may to advantage be flashed into a vacuum drum for the removal of entrained water, so as to give a bright stock.

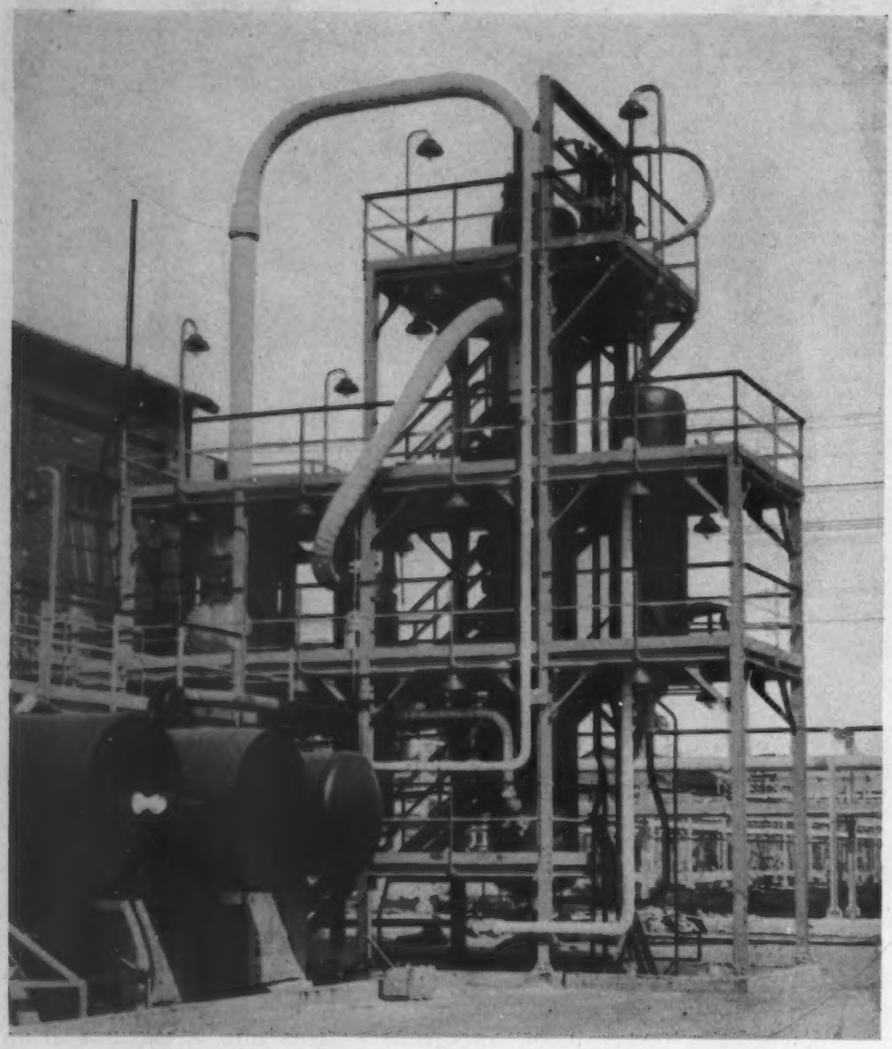
When treating oils containing only a small percentage of wax, the wax discharged from the centrifuges may be stored and run into the solvent-removed still for oil, when the centrifugal plant is shut down. For oils containing a reasonably large percentage of wax, however, a separate solvent-removal still for the wax should be employed.

The overhead solvent vapors and steam from the stills 13 and 15 are condensed in 17 and the water is separated from the solvent in the static tank 18, from which the solvent may be returned to the blending, thus starting the circuit again.

The quantity of solvent to be added to the oil depends on the wax content and viscosity of the oil. For instance, when using trichlorethylene as a solvent the proportions of oil and "tri" usually vary between 60 and 40 parts of oil to 40 — 60 parts of "tri" by volume. This comparatively low dilution means low refrigerating and solvent distilling cost, as shown in Table 1, assuming two different oils and degrees of dilution:

KEY TO CHART

1. Solvent.
2. Waxy oil.
3. Oil preheater.
4. Mixing column.
5. Pre-cooler.
6 and 7. Chillers.
8. Ammonia compressor.
9. Condenser.
10. Ammonia tank.
11. S-N Centrifuges.
12. Pre-heater.
13. Oil still.
14. Dewaxed solvent-free oil.
15. Wax still.
16. Solvent-free wax.
17. Solvent condenser.
18. Water separator.
19. Water to drain.
20. Solvent to storage or feed pipe 1.



Continuous solvent-removal still for S-N Dewaxing plant.

U. S. Gallons of oil to be dewaxed.....	100	
Lbs. of oil to be dewaxed abt.....	750	
Oil No.	I	II
Oil/solvent dilution, by vol.....	55 : 45	40 : 60
U. S. Gallons of solvent.....	82	150
Lbs. of solvent ("tri").....	1000	1830
Chilling the solvent 1°F. requires B.t.u.	230	420
Chilling the oil 1°F. requires B.t.u.....	375	375
Chilling the solution 1°F. requires B.t.u.	605	795
Thus, chilling from 110°F. down to —20°F. requires theoretically (latent heat of wax not included).....B.t.u.	78,700	103,300
Heating the separated oil and wax and distilling off the solvent requires approximately .....B.t.u.	175,000	282,000

The economy of the process is further improved by the fact that the chilling can be carried out comparatively rapidly, owing to the special kind of solvent and type of centrifuges employed. Thus, experience has shown that appropriate precipitation of the wax is usually obtained when chilling at an average rate of 10-15°F. per hour. Only in exceptional cases as slow a chilling as about 8°F. per hour need be resorted to, whereas usually the chilling of the warm oil solution from 110°F. down to —20°F. requires only about 10 hours.

In regard to the degree of chilling it is difficult to give any general rule. As is the case with the proportions of oil and solvent, the chilling temperature has to be adapted to each particular oil, since the difference between the lowest chilling temperature and the pour point of the dewaxed oil varies considerably with different oils.

The loss of solvent through evaporation has proved in practice not to exceed 0.3—0.4 percent by weight of the quantity of oil treated.

The steam consumption for pumps, heating, distillation, etc., may be estimated at 50 — 80 pounds of live steam and 200 — 350 pounds of exhaust steam per 100 gallons of oil. The corresponding water requirements are about 1000 — 2000 gallons.

An S-N dewaxing plant of average size can be operated with three men, one for pumps and refrigeration, one for the solvent still and the third to operate the centrifuges.

Taking all the above mentioned items as well as depreciation, repairs and overhead into consideration, and assuming a total plant cost of about $150,000 for a 500-barrel per day plant, the total operating cost works out to $1.00 — $1.50 per 100 U. S. gallons of oil, depending on the wax content and other characteristics of the oil.

As already mentioned, the results obtained at Port-Jerome were published in the September, 1934, issue of this journal. Some additional examples of results obtained in practice with different kinds of oil are given below:

Example 1.

An unrefined press oil concentrate from Boryslaw crude, having a viscosity of about 230 secs. R. at 120°F. and a pour point of about 23°F. was diluted with "tri" in the proportion 60 : 40, chilled to minus 4°F. in about 10 hours and centrifuged. The dewaxed oil had a pour point of 10.5°F., which was increased to 16°F. by acid refining and finishing with fuller's earth.

When the same oil was first refined (the pour point increasing to 34°F.) and then dewaxed as above, the pour point of the finished oil was about 18°F.

It should be noticed that this oil could not be dewaxed in practice by means of the old centrifugal method using naphtha as a diluent.

Example 2.

An overhead pipe still cylinder distillate from Polish (Shodnica) crude, having a viscosity of 183 secs. R. at 212°F. and pour point 60°F. was dewaxed at minus 18°F. at two different dilutions:

Dilution oil: "tri"	DEWAXED OIL			Melting point of wax
	Pour point	Viscosity Secs. R. at 212°F.	Per cent yield	
40 : 60	21°F.	210	90.1	113°F.
50 : 50	23°F.	202	89	112°F.

Example 3.

An Argentine distillate with a viscosity of 136 secs. R. at 120°F. and pour point 47°F. was diluted with "tri" in the proportion 44 : 55, chilled to minus 33°F. in 10 hours and centrifuged at a throughput of about 120 barrels of oil per 24 hours with the following result:

Pour point of dewaxed oil..... 3°F.
Yield of dewaxed oil.....82 percent
Melting point of wax ..... 85°F.

By treating the dewaxed oil with 75 percent sulphuric acid, 1.2 percent lime and five percent clay, the pour point was increased by only 0.5°F., the cloud point of the finished oil being 8°F., thus only 4.5°F. above the pour point.

Example 4.

A Russian distillate, visc. 90 secs. R. at 212°F., pour point 30°F., was dewaxed as follows:

Dilution 40 : 60, chilling in nine hours to minus 11°F., centrifuging at a rate of 110 barrels of oil per 24 hours. The dewaxed oil had a pour point of 0°F. and solidified without clouding. The yield of oil was about 97 percent, and the wax had a melting point of 123°F.

When treating oils with a high wax content, it has in many cases proved advantageous to carry out the dewaxing in two stages, as shown by the following examples:

Example 5.

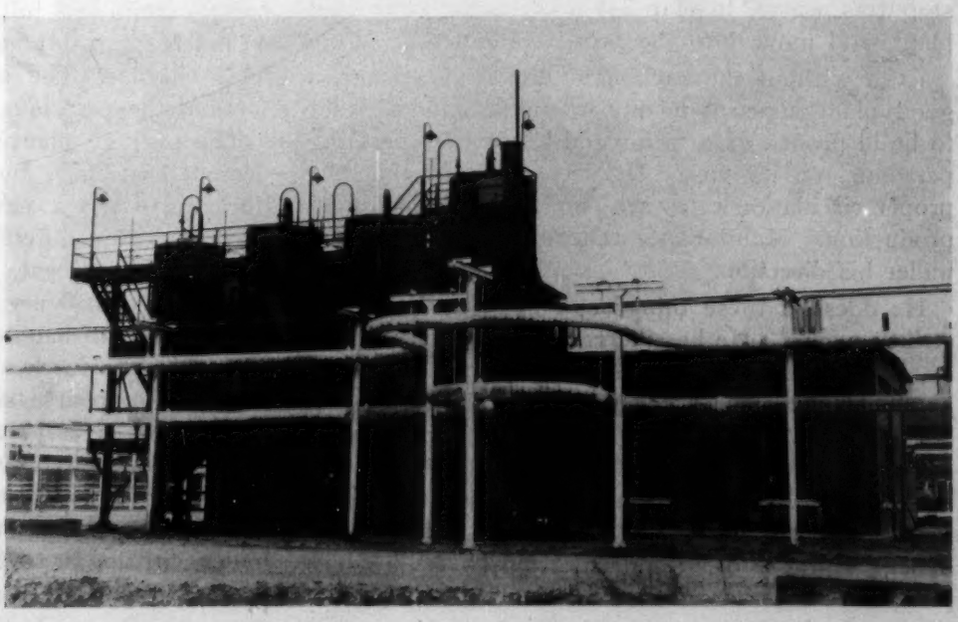
A heavy Roumanian distillate with a pour point of 117°F. and viscosity 77 secs. R. at 212°F. was diluted in the proportion 30 : 70 and treated as follows:

1. Chilling to 5°F. and centrifuging, the wax obtained having a melting point of 138°F.
2. Chilling the separated oil solution further down to minus 35°F. and centrifuging again, the wax thus obtained having a melting point of 110°F.

By thus removing the wax in two stages, viz. first the harder and then the softer wax, a total yield of about 60 percent of dewaxed oil was obtained, the pour point of the oil being about 25°F. and the viscosity 112 secs. R. at 212°F.

It would lead too far to quote here still further examples of results obtained with the S-N method, partly in commercial operation, partly in semi-commercial scale at the S-N European pilot plant. Be it sufficient to say that the S-N process using chlorinated hydrocarbons as a solvent can be successfully employed for almost any kind of oil, whether distillate or residue, whether having a high or low wax content, whether containing crystalline or amorphous wax, whether refined or unrefined, whether solvent extracted or not.

As will be seen from the description and operating data contained in the foregoing, the conditions of treatment, viz. dilution, chilling, throughput, etc., have to be adapted to each particular oil so as to insure the best possible results and economy. The information given, however, will enable the reader to estimate the approximate cost of dewaxing and the results obtainable with the S-N method with any type of particular oil.



Four continuous chillers (crystallizers) for S-N Dewaxing plant.

Old Man Obsolescence

F. L. KALLAM
Industrial Engineers, Inc., Los Angeles, Cal.

MANAGEMENT has been sweating for five years to hold together a skeleton organization and to meet payrolls. No stone has been left unturned. Costs have been cut to the bone. Every sales possibility has been explored. It has been a terrific task to keep the old ship moving against head seas.

For waging this battle, management has required many talents and capacities. With the thousands of responsibilities, however, some things have been overlooked. And some of the things overlooked are important. In considering the average plant, one such item is power.

It is a fact that power services in the average plant cost from 40 to 60 percent of the total cost required to manufacture natural gasoline. Good authority points out that in the average industrial plant 50 cents out of each power dollar is wasted. This should mean considerable to management since it must stand or fall on the field of industrial competition. To succeed, operation must be better than the average. Thus the excessive power cost of the average plant is the measure of competitive opportunity. If your average competitor wastes half of the money he spends for power services, why not stop this waste, insofar as it exists in your own plant, and move into the profit column?

Even without the backing of the management, a good plant superintendent or engineer does a lot to build profits. He trains and keeps the operating personnel on its toes. He sets and sees that the proper circulation rates are employed for maximum production. Maintenance schedules are adhered to under his direction.

He does all these things and more, and then he strikes a snag. He has increased his boiler efficiency, but it is still 10 percent shy of what he should have because of poor setting and inadequate burners. Engine cylinders are continually being broken because of poor cooling facilities and bad water. Coolers are likewise fouling rapidly and plugging for the same reason. Despite his best efforts, exhaust steam still blows to atmosphere because pumps and turbines are not balanced with respect to heating and agitation loads. In short, he cannot correct these costly ills unless the management has some imagination or the engineer enough sales ability to demonstrate the advantage of bigger and better junk piles outside the plant rather than inside.

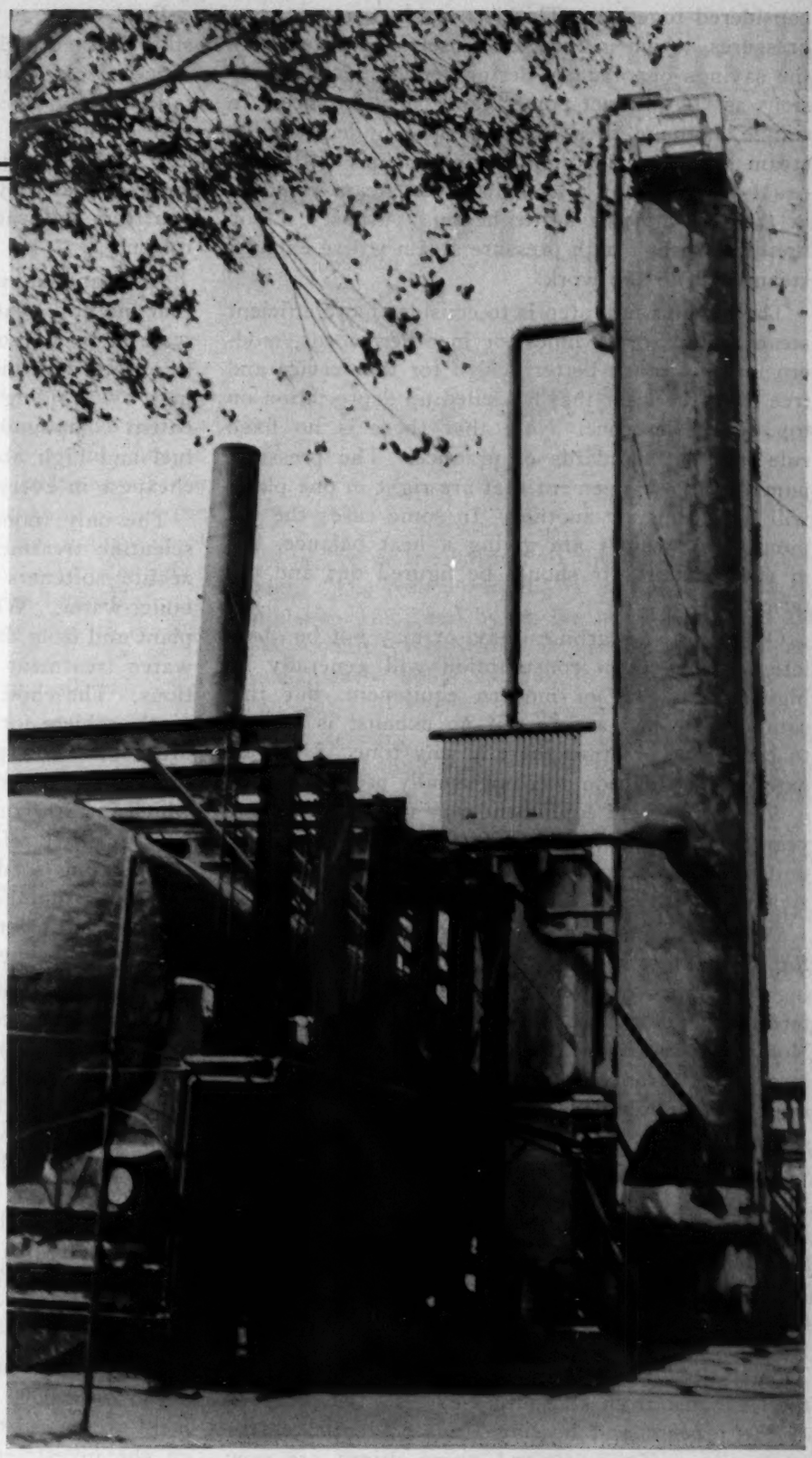
The savings possible from plant modernization are often spectacular. Frequently, $1000 spent now will save $2000 this year, $2000 the next and so on, savings which are truly phenomenal. It should not be necessary, therefore, for the engineer to become prematurely gray trying to sell management the idea of operating at a profit through a program of modernization.

Management obviously needs a truer picture of what obsolete equipment is. Here is the test for your own plant. First decide how quickly new equipment must pay for itself to be worth your while. Say that you pick two years. Then compare the operating cost of any piece of existing equipment with that of the best on today's market. If the savings will pay the first cost of the new apparatus in two years the old is obsolete.

The output of the boiler plant is so many pounds of steam at a definite pressure, made from feed water at a certain temperature. For this output you pay a certain fuel bill, a certain labor bill. You pay so much for maintenance, supplies, supervision and fixed charges. The boiler problem is to keep the total of these various costs as low as possible.

The average plant boiler operates at perhaps 60 percent efficiency, and sometimes lower. It is not difficult to get a new plant that will average 80 percent. This difference in efficiency will cut the fuel bill 25 percent, assuming the same grade of fuel is burned. Very often the new equipment can be arranged to handle a different and cheaper fuel, amounting to further savings.

Age is of course not always a proof of obsolescence. Yet a 20-year old boiler is certainly obsolete unless used only for standby service, since a new one will give 10 to 20 points better efficiency and save its cost in three to four years. Younger boilers, in the 10 to 20 year class may be obsolete, or they may merely require new firing equipment,



Type of small plant which appeared during the period of transition from shell still to tubular retort and bubble tower, and which was soon obsolete.

higher settings or modern furnaces to compete reasonably well with completely modern units.

The large number of old boilers now in operation creates a real problem for the insurance companies. Every owner should consider the possibility that some of his old units may become uninsurable, or insurable only for some lower and dollar-wasting steam pressure. Never start boiler modernization without rehashing the entire question of higher steam pressures. To do so may be a major business and engineering error.

If we think, as we should, of low total steam costs, as well as low unit steam cost, we shall watch consumption. In the matter of savings obtainable by better equipment and hookup, the boiler and power units are about on a par and must often be

considered together. This is notably true of steam pressures, which in turn are closely connected with the savings opportunity designated by such expressions as "by-product power" and "heat balance." In simple language, then, the problem is to decrease the steam consumed by pumps and turbines until it is equal to or slightly less than the steam required in the still and for kettle heating purposes. Stop the direct use of high pressure steam where exhaust steam will do the work.

The obvious first step is to consider more efficient steam pumps or turbines, or in other words, modern units of much better design for the service and free from the wear that has piled up depreciation on top of obsolescence. Note that there is no fixed rule here or standards of practice. The pressure, pumps, and arrangement that are right in one plant, will be wrong for another. In some cases the old pumps or turbines are giving a heat balance, but in every plant this should be figured out and determined.

Old pumps or turbines may, or may not be obsolete. Their steam consumption will generally be higher than that of modern equipment, but this cannot be called a defect if no exhaust is wasted to condenser or atmosphere at any time. Unfortunately, this condition does not usually prevail. Where it does not the old equipment may waste large sums yearly, probably enough to justify the cost of a new unit. Remember, low power cost demands cheap steam and little of it.

Often old equipment is operated under conditions for which it was not intended. Only poor operating economics can result. These cases should be ferreted out, for they probably exist in most plants. Notable cases are the operation of compressors with incorrect clearances or cylinders of wrong size or improper combinations. Plants have been known to operate for years with turbines nozzled for 15 pounds on 45 pounds back pressure, resulting in water rates twice what they should be. It pays to look over the present operations with respect to the operations originally used to select the existing equipment.

Direct steam-driven reciprocating pumps are steam eaters. Their replacement by centrifugal pumps reduces the production of exhaust steam. This is decidedly important in all cases where the total exhaust from all sources exceeds the demands of the process and heating loads. Modern centrifugal pump efficiencies and pump drives are now so high that even 10-year old units are usually obsolete. In fact, there is no place in the average plant where savings can be made so quickly as in connection with the pumping equipment. This is due to either obsolescence or to original unscientific installation, or to changes in operating conditions over those for which the units were initially designed.

Feed water at the boiler should be as hot as possible to save fuel and prolong boiler life. Obsolescence of old heaters is measured by how far they fall short of possible temperatures and also, in the case of the open type, how completely they "deaerate." Modern open heaters are superior in this respect in that they more completely remove the oxygen from the water which is the chief cause of corrosion.

All plant engineers have learned to their sorrow that natural waters, excluding rain water, cause scale in troublesome quantities. Nothing but scientific water treatment is even worth considering. Savings by avoiding cleaning labor, excessively priced patent compounds, burned-out boiler tubes, wasted fuel and high absorption oil temperatures make it cheapest in every case.

The only room for choice is among the various scientific treatments. These include chemical and zeolite softeners as well as chemically controlled boiler-water. Water analysis varies from plant to plant and from day to day in the same plant. Proper water treatment varies with these various conditions. The choice of treatment is therefore a technical problem for engineers trained in such matters. More attention should be given plant water conditions because of its effect upon oil temperature, which in turn controls the quantity to be circulated. This quantity reflects directly upon the plant power and heating load. Management should therefore not forget that 1°F. rise in lean oil temperature, due to water scale condition, represents a decrease in absorption efficiency of two percent.

That opportunities exist in the average plant to reduce present costs is illustrated by the example of a gasoline plant operating centrifugal pumps. A study of the existing and estimated future operations in the light of modern pumping efficiencies showed that it would be profitable to modernize. It was found that the horsepower demand could be cut 28.5 percent, or to 500 horsepower, by the installation of new prime movers and pumps. This program resulted in a decrease of 16.4 percent in the cost of power and steam, or an actual saving of $555 per month. As the new units completely installed cost but $6100, the investment paid for itself in eleven months. And after this period, it saved over $500 a month over the original equipment, representing a return of about 109 percent on the investment. Similar opportunities exist in practically all present day plants. Look for them.

Where management will work hand in hand with the engineer to get 100 cents in service for each power dollar expended, the total production costs will be stepped down from one to five percent. Such reductions immediately gain this competitive advantage over the remaining average plants that continue to neglect this field of saving.

Spent Doctor as a Research Problem

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Turbo-Mixer Corporation, New York

ONE of the most fertile fields for experimentation in the oil refinery, is with spent doctor solution and with the caustic wash preliminary to sweetening. Between the lead lost to the sewer, the oil evaporated off and the final throwing out of the spent caustic, there is enough money going out of the pockets of the refiner to pay for all of the labor of the treaters, where sweetening is important.

As an example of the possibilities in work on this subject, take these:

1. Recovery of all lead from the oil and wash water.
2. Separation of oil from blackstrap.
3. Rejuvenation of doctor solution.
4. Recovery of lead remaining in solution after the caustic is contaminated too badly to be used again.
5. Recovery of contaminants, which may possibly be made to pay for the process.
6. Recovery of caustic from caustic wash.

These six points may be a starting point for a line of work which may lead to one of the smooth running operations which pay their own way.

It seems elemental to suggest that the reason for a high litharge bill is that lead is being thrown away, but many refineries with good doctor rejuvenation systems are spending hundreds of dollars a month for makeup lead. Practically the only outlet for this lost lead is to the sewer so it is not unreasonable to suggest that a little work on finding the extent of these losses, locating the leaks and changing the procedure so as to save all of the lead, will amply pay for itself. With the lead that gets away goes a good quantity of oil also, for the two hang together tenaciously.

The rejuvenation of spent doctor is common practice in most of the refineries today, but the problems relating to the process are far from solved. Thousands of barrels of oil are wasted each year in this process, because of the difficulty of separating the lead sulfide from the oil. No research organization in the industry should complain of a lack of a research problem while this particular one remains unsolved. It consists of a lot more than the mere breaking of an emulsion, although that, in itself, is no mean opponent for the cleverest of the research men, for this is one of the hardest of the emulsion types to break. The reason for this is that it is one of the emulsions stabilized by an insoluble solid, lead sulfide in this case, which is in the oil phase and consequently holds caustic, in emulsion form, in the oil.

One refinery is said to use sulfur in excess, to bring about the break, but this has the disadvantage of forcing them to rerun the separated oil. An ideal method, here, would give a clean break immediately after the sweetening operation, before the oil has had a chance to discolor. Probably everyone who has worked with these emulsions has noticed that after the blackstrap has stood for a few hours, the oil which separates out is quite brown. The oil on evaporation leaves a heavy layer of gum in a dish, sometimes sticky and sometimes varnish like. If the oil is to be used without rerunning, it must be separated immediately after the sweetening.

Another of the large refineries is centrifuging the blackstrap and accomplishing this very thing (Refiner, Vol. 13, No. 3, March, 1934, Page 88). The oil is apparently unchanged and can be run to storage. The action here is merely the accentuation of the gravity force by centrifuging to the point where the heavy lead sulfide is thrown away from the caustic droplets enough to allow them to join together to form a layer. The lead sulfide is not all thrown into the caustic layer, but deprived of the tenacious caustic-oil interface, it can be easily settled out. This seems like a fair solution to this special problem, but there may be a very much simpler one just around the corner, waiting for some good work by one of the research organizations. The returns here are sure, probably much greater than appears on the surface, for the losses from this source are not easy to figure, in fact are a lot easier to pass over with a wave of the hand, denoting indifference.

One of the most common means for accomplish-

ing the break, not very successfully, however, is to heat the blackstrap to a temerature of from 150° to 180° F. in an open tank. In one refinery it is reported that if this is done in the bright sunlight it is much more successful than if the sun is not shining, and this may prove the benefit of ultra-violet light. The disadvantage of this system is that the most volatile portion of the oil takes the shortest path to heaven, leaving a greatly concentrated solution of gums to gum up the doctor recovery step. The oil which does separate is high in gum also, and must be rerun. At its best, this is a makeshift method. It is never complete, and the oil and gum remaining with the lead interferes with the subsequent recovery of the latter.

The presence of this oil with the lead sulfide, gives an interesting slant to the recovery operation. In this operation the object is to get the oxygen to the lead sulfide so that it can be converted back to sodium plumbite, but this action is complicated by having to be accomplished in four distinct steps which may be divided into:

(a) The oxygen from the air must dissolve in the caustic solution.

(b) Since each particle of lead sulfide is coated with an oil layer, the oxygen which is in solution in the caustic must transfer itself to this oil film, either as a solution of oxygen in oil or more probably as a peroxide.

(c) This must then give up its oxygen to the lead sulfide which oxidizes.

(d) This oxidized lead compound must be washed away from the oil by the caustic in which it is soluble.

All of this sounds complicated, and if these steps had been realized by the first man to oxidize lead sulfide in this way, it might have discouraged him before he started. Fortunately he did try it out, and the system worked.

The story of what happens to the oil is as interesting as that of the oxygen. Some oil invariably goes into the oxidizer and immediately starts to vaporize, aided by the heat and the air being passed through the liquid. The oil at this stage prevents any foam from forming, probably due to the action of the fumes in lowering the surface tension of the air. Probably for the same reason, the air bubbles are coarse during this stage.

The most volatile fractions pass off easily as the heat increases, but a part of the oil never does go off. The fine lead sulfide is still keeping this oil as the external phase to a small portion of the caustic, as the microscope will show, but this oil and sulfide mass is, in turn, in the internal phase of the main batch of caustic. The former is a very stable form, while the latter is highly unstable.

Since the oil is still present in sufficient quantities to hold the specific gravity of the oil and sulfide mixture above that of the caustic solution, it will be found mostly floating on the surface. As the oil vaporizes, however, the specific gravity will increase until it is higher than that of the solution, when it deserts the surface and drops into the caustic.

By this time an old doctor solution may show a peculiarity which may make it very difficult to handle. The oil, coating the lead sulfide, may have evaporated so far that sticky gum is left on the surface of the lead. When this happens with ordinary air blowing, the sulfide is liable to form into lumps, possibly as large as a man's head, while with a modern turbo-oxidizer it will form into perfect globules, about the size of fine sand. Examine some of the sediment from the oxidizing tanks and you may find this in your own plant, since it is very common.

Usually, however, enough oil remains to keep the particles from adhering, but so long as the lead sulfide lasts the mass keeps its power to hold caustic. As soon as the sulfide is all oxidized, the story changes, and the oil which throughout the oxidation has kept the power to hold caustic as an emulsion, finds the power gone and promptly emulsifies in the caustic to form a very troublesome mess. Settling is all that is needed to get it out, since the difference in specific gravity between the oil and the caustic is ample for fairly speedy separation.

This stage is shown when a jelly-like layer forms on the surface of the liquid in a sample bottle which has been allowed to stand. This is very puzzling, when first seen, but the microscope tells the story. The best way to eliminate any trouble from this source is probably to finish up the oxidation with a few gallons of signal oil which will not only collect this emulsion of gummy oil but will also hold back the coloring compounds which the gasoline might wash out later, to its detriment.

In those cases where the oil evaporates almost completely and the gum misses the sticky stage, the only indication of the presence of gum is a tarry ring around the edge of the oxidizer and settling tank, and this is always the worst to be expected when the oil is almost completely separated from the lead before oxidizing.

The history of the sulphur is interesting only as it effects the contamination of the doctor solution by the gradual building up of the thiosulfate concentration. Possibly even this is not as inevitable as it looks and might respond to a little pressure from the research department, in which case the doctor solutions could be rejuvenated many more times than is now possible.

Thiosulfate is not the most serious contaminant,

however, for the newer cracking processes have brought a worse one to the front. Doctor solutions were practically all yellow in color after use, but now red predominates. This is due to the phenols and related compounds which have been dissolved out of the cracked gasoline. The coal tar people class these crude mixtures under the general term "carbolates", a term which could be adopted by the oil industry as well.

By a peculiar chance some of these substances have been attracting attention as solvents for the new lube processes as well as for antioxidants for gasoline and lubes. An unfortunate circumstance is that they also act as antioxidants in the oxidation of lead sulfide, which lends credence to the theory that the oxygen passes through the oil to the lead sulfide as a peroxide. The fact of the matter is that the gasoline refiner is now in the phenol business whether he likes it or not, which again introduces the research laboratory.

The new problems presented by this development, which may be solved by research and may even be turned into money makers, are:

1. The oxidation rate in the doctor recovery units is seriously lowered.
2. The doctor solution is badly contaminated.
3. The disposition of the carbolates.

The rate of conversion of the lead sulfide to sodium plumbite affects the cost of this operation seriously, so a method of removing the contaminants or of neutralizing the inhibiting effect offers promise of more than repaying the research cost. This problem is so close to the inhibitor problem that the two could be paralleled with very little expense.

Some refineries have reduced the contamination of the doctor solutions very materially, by introducing a thorough caustic wash ahead of the sweetening step. On the face of it, this looks like a wise step, for it gives a chance to recover both the carbolates and the caustic.

Recovery of these carbolates is now being practiced in the coal tar field as a part of their regular procedure and the adaptation of these methods to the refinery conditions should not be a serious job for the research department.

The general method for accomplishing this is by passing flue gas through the carbolate solution until the caustic is all converted to carbonate. The carbonates are held in solution until the very end of the process, when they separate out as an oil. If this process can be made workable in the refinery, the oil may find a ready market in the oil industry itself.

Simple equipment is available for the gas absorption step, and the operating cost should be very low. Problems of concentration and control offer a field for research which may not only bring a good return, but which may ease up considerably on the problem of river pollution. Phenols are a thousand times more troublesome in the purification of water for drinking purposes than are the hydrocarbons.

The carbonate solution, left after the removal of the carbolates, may be sufficiently pure so that it will yield a usable caustic solution again, if treated with lime. This is the well-known causticizing process, extensively used in many industries. Lime is cheap and is the only reagent necessary. The equipment is simple, especially when the batch process is used. A lime slaker and a tank fitted with an agitator, with a means for heating the liquid, is the minimum equipment needed. It may be necessary to bring this solution up to strength by the addition of caustic, but this will not be more than enough to make up the losses.

Recovery of the small amount of lead left in the spent doctor solution, when it is too badly contaminated to be of any further use, should be fairly simple, especially if sulfide solutions from some hydrogen sulfide removing wash are available. If this operation is carried out in a separate tank where settling can take place until it is time to throw out another batch, the collected lead can very easily become a nest egg when it is suddenly found to have built up to a batch amounting to tons. The bill for lead in the refinery is a considerable item, even where recovery is used, and any way of reducing it is money in any language.

The object of this article has been to show that there are some research problems in the back yard of the refinery which may be made to pay their own way and improve the process at the same time. It is thought that if as much work had been put on doctor sweetening as has been devoted to methods to supersede it, the problems would have been solved long ago.

Inspection of

Oil Refinery Equipment

PART 2

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III—METHODS OF CONDUCTING INSPECTIONS

THERE are many ways of determining the suitability of equipment for the service it is to render. Methods applicable to one kind of equipment may not be applicable to another kind. A number of different methods and their general application will be given. However, each inspector will have to use his own judgment as to the method or combination of methods necessary for each particular piece of equipment. In addition, he will undoubtedly, at times, find it necessary to devise new methods. The tools and instruments required to carry out these inspections will be described later.

CYLINDRICAL OR SPHERICAL VESSELS

Visual—Where the size of the vessel and internal arrangement is such as to permit, the inspector should enter the vessel and give it a thorough visual examination. Where the inside of the vessel is coated with tar, coke or anything else, it should be thoroughly cleaned by wire brushing, sand blasting or other means. During this examination careful note should be made of any pitting, grooving, cracking, checking, scaling, bulging or other irregularities, or doubtful conditions. Points, where defects or doubtful conditions are found, should be further investigated by other methods (later described) to determine the amount of sound metal remaining.

Where the size of the vessel or internal arrangement will not permit entry, the interior should be given as thorough a visual inspection as possible through all openings and any unusual conditions should be noted and investigated.

In the case of lined vessels, particular care should be taken to see that the lining is in good condition and is protecting the metal beneath it. The need for any repairs to the lining should be carefully noted and request for such repairs should immediately be made.

During the internal visual inspection, all interior equipment should be carefully examined. Particular attention should be given to the supports of pipe coils, trays, pans and so forth to see that they are adequate to carry the load. When cast iron pans and trays are used, they should be carefully examined for cracks.

In riveted vessels the heads of all rivets should be examined for corrosion, undercutting or other signs of deterioration. The condition of rivet heads gives a quick and reliable indication of the location of the most severe corrosion. The wall thickness of a vessel should be carefully determined in the vicinity of the most seriously corroded rivet heads.

The condition of all attached piping, nozzles, manheads, and so forth, should be observed from the interior of the vessel.

The exterior of all vessels should be carefully examined for signs of leakage and if uninsulated, any unusual conditions, as outlined above, should be noted. In the case of insulated vessels, it is sometimes customary to make the insulation over the joints easily removable. In such cases this insulation should be removed and the exterior of the vessel given a careful visual examination at such points. Whenever the insulation is removed from any part of a vessel for any reason, the exposed surfaces of the vessel should be given a careful visual examination. Where distortion, such as bulging, is indicated by inside examination, the insulation should be removed in that vicinity and the outside carefully examined.

During the external inspection, all attachments to the vessel should be observed and particular attention should be given the supporting members to see that they are in condition to carry the load.

The above method of inspection is applicable to any vessel and should always be made.

Sounding or Hammer Test—Several conditions can best be revealed by use of a hammer.

Where the wall of a vessel will vibrate under the blow of a hammer, material differences in thickness can be detected by the change in sound. Inspectors experienced in sounding the wall of a vessel can readily determine the location of the thinner areas.

Tapping the head of a rivet with a hammer will show whether it is tight or loose. Frequently this can be determined by the sound. At times it is necessary to determine this by "feel"; that is, the finger or finger nail

Regardless of the exact type of organization employed for carrying out the details of inspection, it is felt that the inspection forces should not be directly under the jurisdiction of those primarily in charge of either production or maintenance of the equipment. Where there is an independent technical organization, it is felt that the inspection forces should come under such an organization so that they will be free to express their opinion concerning the condition of the equipment and the character of the maintenance without being influenced by some one whose primary interest is either in getting the maximum out of the equipment or of maintaining it at the lowest cost. Freedom to state conditions exactly as found and to criticize the condition of the equipment without fear of jeopardizing their positions is one of the prime requisites of a successful inspection organization.

is placed against the side of a rivet head and the opposite side of the rivet head is struck a quick sharp blow with the hammer. The vibration set up in a loose rivet can readily be felt in the finger against the rivet.

After an inspector becomes accustomed to detecting changes in sound of hammer blows and to the "feel" of a hammer striking different surfaces, it will be found useful in many cases. In fact, an experienced inspector will seldom be found without his hammer and he will use it liberally and will detect many things by its use.

Thickness Determinations—There are a number of different methods for determining the thickness of a vessel and the proper one to use is dependent on the thickness of the vessel and its position.

(a) For determining the thickness of a vessel from 3/16 to 2 or 2½ inches thick, it is usually feasible to drill small holes at the points one desires to investigate and later tap these holes with a pipe or taper tap and plug them. A convenient sized hole is one drilled with a 17/32- or 9/16-inch drill and such holes can be tapped with a ⅜-inch pipe tap for plugging. If plugs are installed with graphite and oil, they can be removed, at future inspections, to take check measurements and keep a running record of corrosion occurring. A plug having a square head is preferable since a tee handled socket wrench can be used for tightening and removing, thus doing away with eccentric strains which sometimes cause breakage during removal. When test holes are plugged it is preferable to insert the plug from the inside where possible, unless cleaning or other operations are liable to damage the plug. When inserted from the outside of the vessel it is preferable to use a straight taper thread since the plug should be screwed in until at least flush with the inside surface. If this is not done, corrosion will cause the hole to enlarge and make future thickness measurements difficult. When plugs are inserted from the inside it will sometimes be found that the metal immediately adjoining them does not corrode quite as fast as the metal a short distance away. This can be easily determined by laying a short straight edge across the hole, after the plug is removed. If this shows a collar around the hole, the height of this collar can be estimated or measured from the ends of the straight edge and deducted from the thickness measurement.

(b) When the thickness of metal in a drum is definitely known and it is not considered desirable or feasible to drill holes for determining future thicknesses, the depth of corrosion may be determined by establishing protected surfaces at predetermined points on the inside of the vessel. These protected surfaces may be obtained by welding corrosion resistant strips or buttons to the inner surface of the vessel. If these strips or buttons are of such material that they are free of all corrosion, original measurements may be taken from their surfaces to the surface of the vessel wall and any future increases in such measurements will represent the amount of corrosion which has occurred. When the protective strips or buttons are not entirely free from corrosion, they should be removed and the depth of corrosion measured from the protected surface under them.

(c) When corrosion resistant strips or buttons cannot be used due to possibility of damage from cleaning operations or for other reasons, and when the metal is too thick or it is otherwise not considered desirable or feasible to drill holes completely through the wall of the vessel for thickness measurements, small holes may be drilled on the inside at suitable places, to a depth at least equal to the metal thickness allowed for corrosion. The original depth of these holes should be measured and recorded and any loss in depth, at future inspections, will represent the corrosion which has occurred. These holes should always be plugged with protective material to prevent corrosion at the bottom. Since metal plugs screwed into tapped holes are liable to break off during removal and the depth of the hole may be affected by drilling out such broken off plugs, it is better to use a material which can be easily removed. Arc lamp carbons, slightly tapered and driven into the hole and then broken off flush with the surface have been found very satisfactory for this purpose. At future inspections these carbon plugs can be easily broken up with a blunt tool and the pieces blown out of the hole.

(d) When it is necessary to determine the wall thickness of vessels and it is not feasible or desirable to drill completely through the wall, parallel wires may be used.

When the vessel is vertical these wires may be suspended from a frame at the top of the vessel and weighted with heavy plumb bobs. (See Figure 4.) Piano wire should be used and the plumb bobs should weigh enough to hold the wire taut. Bobs of a pound weight or more have been found satisfactory. If these wires are exposed and wind tends to cause them to sway, the plumb bobs may be immersed in buckets of

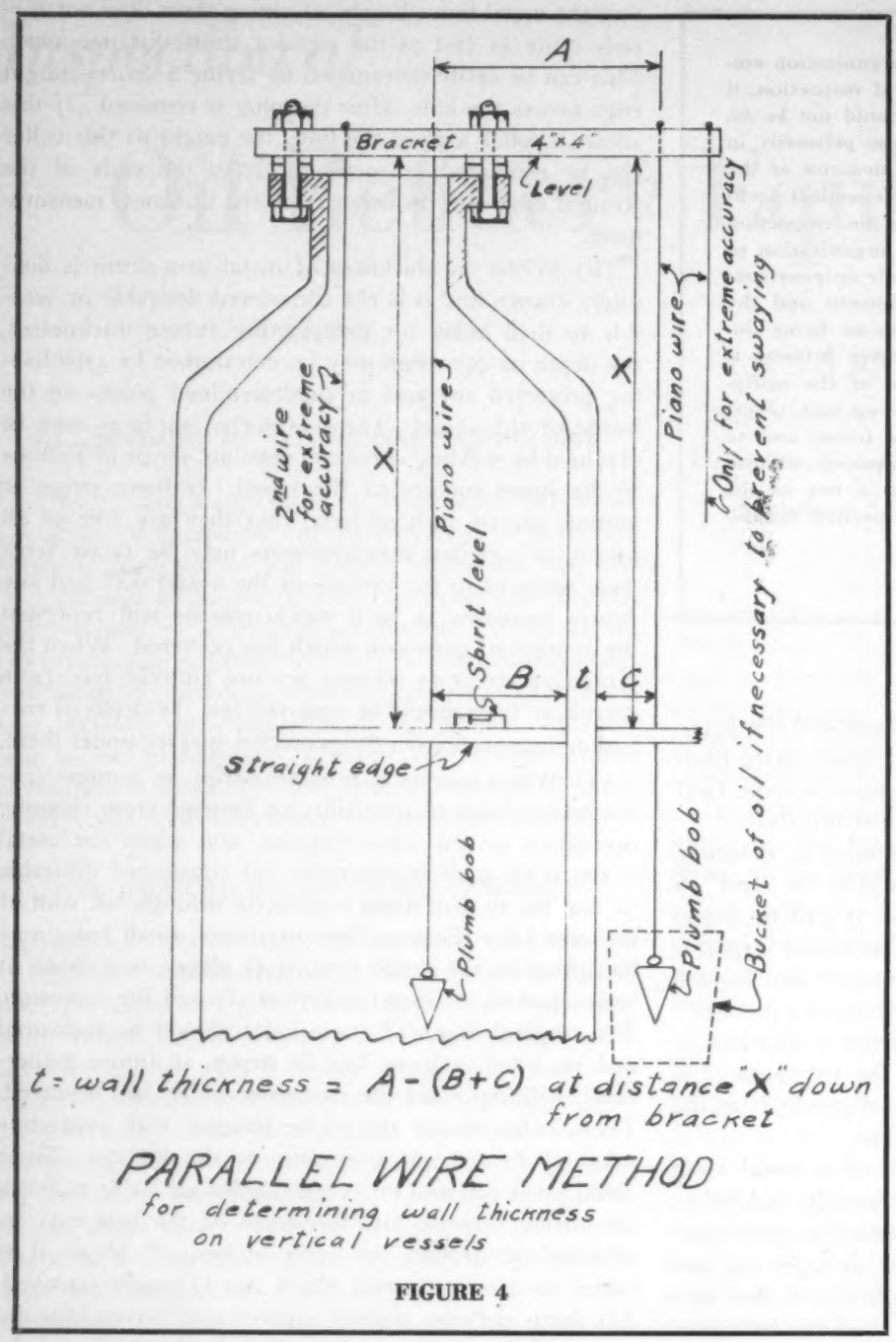

FIGURE 4

heavy, viscous lubricating oil, care being taken that the bobs do not touch any part of the bucket. Where extreme accuracy of measurement is required, it is advisable to suspend two wires inside and two wires outside of the drum, all four wires being in the same radial plane. However, for most practical purposes one wire inside and one outside will give sufficiently accurate measurements, since this method will usually be employed only on thick walled vessels where variations of 1/32-inch, or even 1/16-inch, will have very little effect on the factor of safety. Measurements taken in this way have been found to be accurate to within 1/16-inch and closer on vessels having walls from five to seven inches thick, the check being made by drilling completely through the vessel wall at points previously measured by the parallel wire method. To determine thickness by this method, the distance between the inside and outside wire should be accurately measured. Then measure from the inside wire to the inner wall of the vessel, using a solid metal rule or straight edge. A spirit level should be held or fastened to the straight edge as the measurement must be taken with the straight edge horizontal. The point at which the measurement is taken should be accurately measured, by means of a steel tape, using some fixed point above the top of the drum as a datum. Next, measuring down an equal distance on the outside wire, the distance from this wire to the outer wall of the vessel should be determined in the same manner as described for the inside of the drum. The sum of these two readings deducted from the distance between the wires will give the wall thickness. By measuring the distance from the datum plane to the surface of the top manhead, and identifying the radial direction used, the location of the point measured can be accurately recorded for future reference.

For horizontal vessels having a manhead at each end, an adaptation of the above method can be used. (See Figure 5.) In this case a bracket is fastened to each manhead. Two piano wires are fastened to the bracket at one end, one wire passing through the interior of the vessel and one wire running outside the vessel. The other bracket is equipped with pulleys spaced so the wires will be the same distance apart as at the first bracket. The wires are passed over the pulleys and loaded with equal weights. The weights should be sufficiently heavy to allow only a slight catenary in the wires. The tension in both wires being equal, the catenary of both wires will be the same and can be neglected since they will be the same distance apart at all points. The same procedure for determining wall thickness is used as in the case of vertical vessels, except the spirit level is used to keep the straight edge either vertical or horizontal, dependent on the point being measured.

Since the methods described above are difficult to apply and require considerable time, they are usually

used only to determine wall thickness at certain selected points. The thickness at these points is afterwards determined by the corrosion loss methods as described under (b) or (c). They are also used for determining the amount of sound metal remaining after defects have been removed or for establishing new corrosion loss datum points in places where unexpected excessive corrosion has occurred.

(e) In some cases wall thickness may be estimated by measuring the inside diameter with inside micrometer calipers. In such case the wall thickness must be figured as one half the difference between the inside and outside diameters. Since most of the corrosion found in petroleum vessels is not uniform, this method may result in considerable error and should not be used if the thickness can be determined by any other method.

One of the above described methods for determining wall thickness must be used to secure the necessary data for computing the safe allowable operating pressure.

PRESSURE TESTS

New vessels or those which have undergone extensive repairs (resulting in replacement of major parts or reconstruction of principal joints), should be subjected to a pressure test. The test pressure should be computed for the weakest part of the vessel, using the full wall thickness and a stress equal to 1½ times the maximum allowable working stress of the metal at the test temperature. The pressure should be applied slowly and held for sufficient time to permit examination of the vessel for any leaks or signs of distortion. Water is considered the best medium for applying such a test. *An expandable medium should never be used* for applying this test.

During a regular periodic inspection or after ordinary repairs, the above described pressure test is not considered necessary. In order to assure that no openings have been left in the vessel and that all manhead covers, handhole covers, pipe connections, etc., have been tightened, a steam or inert gas pressure test, somewhat lower in pressure than the normal operating pressure, may be advisable. During this test, the vessel and all of its connections should be carefully observed for signs of escaping steam or inert gas.

Vessels that have component parts, the strength of

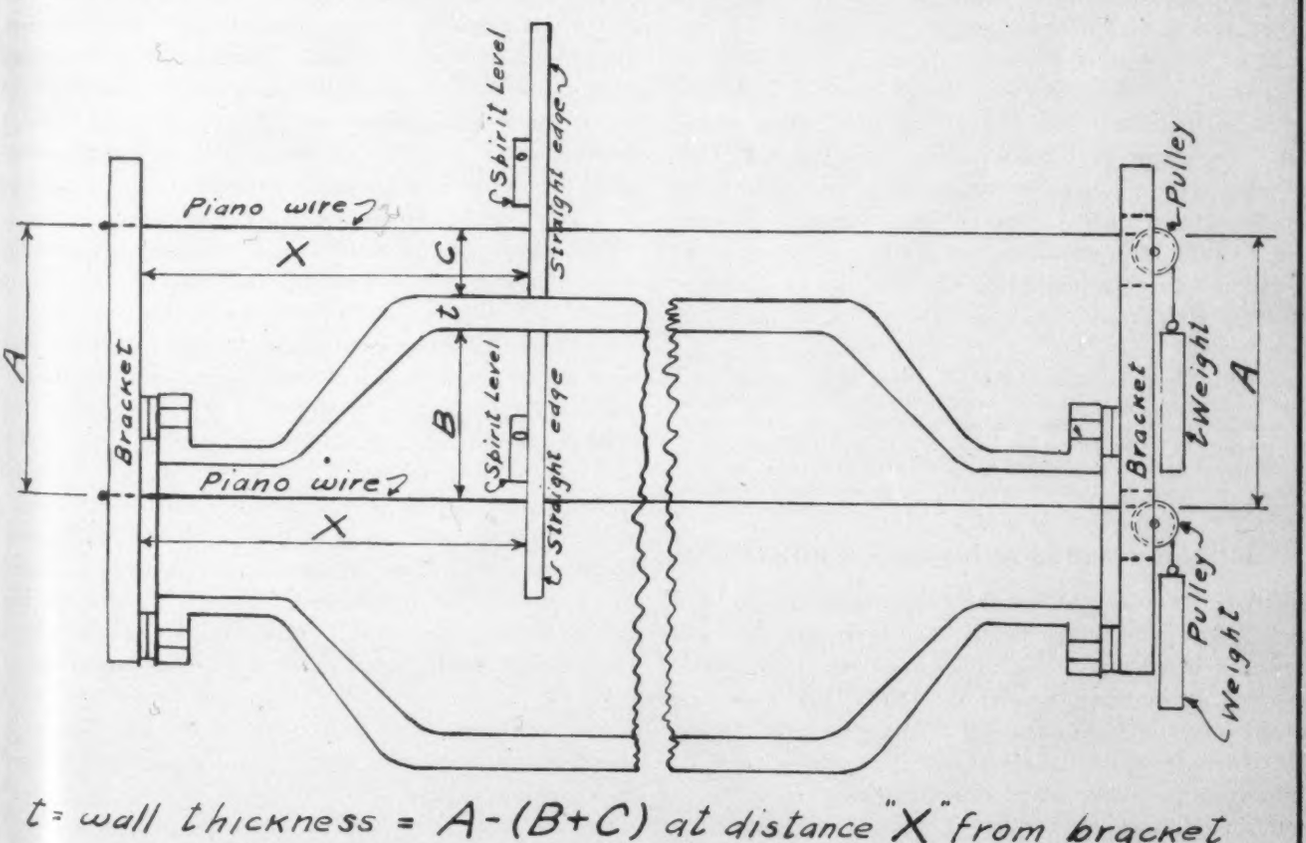

FIGURE 5

which cannot be satisfactory computed, should be subjected to a proof hydrostatic test. The allowable working pressure at atmospheric temperature should be computed for all parts of the vessel where possible. In making these computations the full wall thickness and the maximum allowable working stress at atmospheric temperature should be used. The parts of the vessel which cannot be satisfactorily computed should be coated with a lime wash or other brittle material. Only one coat should be applied. After the wash is thoroughly dried, a test pressure should be gradually applied until either a pressure equal to 1½ times the computed allowable working pressure is reached or until strain lines or flaking off of the brittle coat indicate yielding of the material in that part of the vessel. When either of these points is reached, the pressure should not be increased further. If the final test pressure is 1½ times the computed allowable working pressure, the allowable working pressure may be established as that computed. On the other hand, if the final test pressure is limited by the yielding of a part of the vessel which could not be satisfactorily computed, the allowable working pressure, at atmospheric temperature, should be assumed as 60 percent of the final test pressure. For temperatures above atmospheric, the pressure should be reduced in accordance with the reduction in strength of the material of which it is constructed. (For more detailed description of this test see paragraphs W-526 and R-526 of the A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels for Petroleum Liquids and Gases.) This test may also be applied to an entire vessel which cannot be satisfactorily computed for strength. In such case, extreme care should be taken to raise the pressure slowly and to stop increasing the pressure at frequent intervals to permit close observation of all parts of such vessel.

It is always necessary to employ several of the above methods when inspecting vessels. The visual examination should always be made. Sounding with a hammer is usually employed to a greater or lesser extent. The thickness must be determined by some reliable means and usually one of the methods described will be applicable. A pressure test with steam or inert gas to detect openings or untightened joints is usually advisable.

FURNACE TUBES AND HEADER BOXES

Visual—Internal—After the tube headers have been unplugged or the return bends have been removed, and the tubes have been thoroughly cleaned, the tubes should be given an internal visual inspection. This inspection should be made from each end of the tube as it is difficult to determine the nature of defects too far away. To illuminate the tube, an electric light can be inserted from the end opposite to that from which the inspection is being made. It is usually helpful to have a long handle on the light so that it can be inserted to any desired point in the tube to get the best illumination on any doubtful spots. This method of illumination will tend to magnify any bulges, cuts or other depressions in the tube, due to the shadow which will be thrown. Also eccentricity of corrosion or the tube wall will be apparent. All defects should be carefully noted and an effort should be made to classify them. While making the internal inspection, the end of the tubes should be carefully observed excessive thinning and see they are properly flared.

At the same time this inspection is made, the interior and exterior of the header box should be inspected. The interior of the box should be observed for pitting or other signs of corrosion and for cracks. If necessary, it may be sand blasted to remove coke and other deposits. The exterior should be observed for cracks and distortion. If doubtful conditions are noted, it may also be advisable to sand blast the exterior to remove rust and dirt.

Visual—External—When the firebox is cool enough to permit entry, a visual inspection of all tubes, which can be seen, should be made. Any sign of scaling, overheating, bulging, cracks or other defects should be carefully noted. Careful note should also be made of bending or sagging and, where there is more than one row of tubes, of any "nesting" of tubes which would prevent proper circulation of furnace gases.

Measurements—Internal—Obviously, it is impossible to make an accurate check of the wall thickness of a tube due to its length. Even if special calipers could be devised for this purpose, obstructions such as header boxes, tube spacer sheets, intermediate tube supports, etc., would prevent their use. Therefore approximations of the tube wall thickness will have to be made from the inside and outside diameters. Where little corrosion is experienced it may be sufficient to take inside diameters with a pair of long calipers, reaching into the tube as far as possible. However, where severe corrosion is experienced, this is usually not sufficient because the corrosion may not be uniform and may be much more severe near the center of the tubes than at the end. In such cases it becomes necessary to use a special "tube micrometer" with which measurements can be taken to the middle of the tube from either end. Since these are special instruments not made commercially, it is necessary to make them locally. A sketch of a very satisfactory and comparatively simple "tube micrometer" will be given with the description of tools and instruments required. After an inspector becomes accustomed to the use of this instrument, bulges, cuts and the like can be detected by "feel" and located accurately and it becomes an invaluable adjunct during the inspection of tubes.

The wall thickness of header boxes can usually be measured by indicating calipers, using specially shaped legs on the calipers.

Measurements—External—External measurement of tubes is necessary only at points where bulging or eccentricity is noted since the outside diameter tolerance of a tube is less than the error of internal diameter measurement or the error resulting from assuming the wall thickness to be one half the difference of the diameters. Such outside diameters as are required can be readily taken with ordinary outside calipers.

Depreciation . . .

L. C. TRESCOTT

THE meaning of the word depreciation is an elusive thing. It may be one thing to the technical man, another to the accountant or financial man. Public utility concerns look at it differently than do manufacturing plants. The bond holder sees it in one light while the owner of stocks on which dividends are to be paid sees it in another. It is of interest to dig in a bit and see what it means to those who are primarily concerned with the refining of petroleum.

Those who can look back over fifteen years or more of the oil business have probably seen more radical changes in ideas, processing and equipment than have occurred in any other industry. For many years the change in petroleum products was slow. Distillation methods were comparatively simple. Crudes were either run to coke, or with steam to leave residual products in the still, the resulting overheads being reduced to specification in shell stills by batch methods. Lubricating stocks were finished by old and established methods of acid treating and percolation to color through coarse clay. Had an old timer been questioned as to the life of a filter or an agitator he would probably have answered "forever." Instances are not uncommon where such have been in use for forty years and are still going. While shell stills required more repairs than the finishing equipment, their actual life was of such length that the matter of depreciation was one of more interest as an accounting item than as a burden on operating expense. Gradually as increased production became necessary, single shell stills were expanded to continuous batteries, but there was little actual change in operation or increase in the general wear and tear.

OBSOLESCENCE

With the improvement in automotive engines new and sudden calls came on the industry. Old grades of lubricants suddenly became unsatisfactory. Instead of boiling point requirements only, where any gasoline that came within such specifications was satisfactory, a new proposition of "anti-knock" came up. Certain high grade crudes were for a time almost eliminated so far as their gasolines were concerned. Instead of simple distillation and reduction, the various cracking processes developed. Continuous processes were necessary to effect reductions in operating costs. Automotive improvements required better lubricants than could be produced in the old shell stills and here again increased production forced continuous distillation on the industry.

In the finishing of lubricating oils the use of fine clays and "contact filtration" processes came in. The centrifuge replaced cold settling in dewaxing cylinder stocks and residuals. Continuous acid treating processes were developed for both naphthas and lubricating oils, and now we are facing the new proposition of solvent treatment and propane dewaxing.

In the course of all this change we have seen large and expensive equipment developed, used for a comparatively short time, and then in order to keep up with the procession, discarded and replaced with something even more modern. *So far as depreciation is concerned we have moved from a period where equipment lasted forever, where a low annual depreciation rate could be applied until it was written off altogether, to a period where obsolescence rather than wear and tear is the controlling factor in the active life of equipment.* From a thing of little importance, of interest more to the accountant than to the engineer or operating man, the swiftly changing times have made the matter of depreciation one of the prime factors for consideration in the installation of new processes and equipment.

Perhaps before going too far into this discussion it may be as well to define depreciation, to say what it includes, and how it is accounted for. On the face of things this may seem unnecessary but it will be found in more cases than not that the average business or technical man has rather hazy or at least limited ideas as to what is covered under this head.

Depreciation is the term applied to the decline in value of fixed assets. Just what does that mean? Most men in business are familiar with that definition, but when it comes to a clear idea as to its exact meaning they find that complications as to the method of determining the actual decline in value; the part that repairs and maintenance play in the life of equipment; and the early retirement of equipment due to inadequacy or obsolescence make depreciation something of an elusive proposition. They generally end by charging off a fixed percentage of the value each year and letting it go at that.

But what does this decline in value cover? Can we base it entirely on the difference between the original cost of the equipment and its scrap or second-hand value if it were sold today? A still produces just as much, earns just as much as it did when it was installed and is likely to do so for many years to come. Does this production or go-

ing value have no bearing on the matter of depreciation?

It is true that many authorities estimate depreciation entirely on the normal wear and tear during its productive life, and in many cases this is fair and safe enough, but if we are to safeguard the invested capital in these changing times, this is hardly going deep enough. Under the old conditions obsolescence rarely required any great amount of consideration. Changes in petroleum products were handled in the regular equipment, usually with little change. Now, with expensive process and equipment going out of date almost overnight, other considerations than the actual life, or normal wear and tear must be taken into account in setting the annual figure for depreciation.

DEPRECIATION RESERVES

There are cases, as in utility valuation, where the "going" value of properties comes in for consideration, but in the oil business we are not concerned with values for rate setting purposes. And here, perhaps, is a good place to bring in the primary reason for setting up a depreciation reserve. This should be especially noted as it underlies all ideas of such reserves as they apply to our problem.

A depreciation reserve is set up to protect an investment against loss due to wastage, wear and tear, obsolescence, or to any other item which may cause a loss of value to fixed assets.

If this be kept in mind it helps to clarify the whole matter of depreciation and aids in building up ideas to fit any case.

As we are concerned with fixed assets and as the setting of a "going value" is at best a difficult job, it is better to leave it entirely out of the picture. And if we are to maintain our capital we must consider not only wear and tear, but must also estimate and take into account the risk of a sudden change lowering or wiping out altogether the value of our investment, and set our depreciation rates accordingly.

The fixed assets in which we are interested are the items of refinery equipment. As a simple example suppose we have a still costing $100,000. After a useful life of, say, twenty-five years this is dismantled and sold as scrap for $1000. The depreciation in this case amounts to $99,000. This is a regular operating expense and should be spread over the twenty-five years of its life, just as the operating costs or repair costs on this unit are spread over any single accounting period.

From the above it will be seen that if we are considering wear and tear only, three values must be determined before the amount of depreciation is known: The original cost of the equipment, the length of its active life and its salvage value. Where obsolescence is brought in its effect is to shorten the active life, and it may or may not affect the salvage value.

The first of these necessary items can easily be determined. Usually it is possible to estimate the salvage value, which estimate will come close to the actual second-hand or scrap value. The active life, however, is likely to be a matter of some uncertainty, particularly as it is controlled more often than not by unforeseen conditions rather than by a normal, regular amount of wear and tear.

WRITE-OFF

Once the period which the depreciation charges are to cover has been decided upon, it is the custom to write off each year a certain portion of the original cost of the equipment. There are several methods by which this is done:

1. Percentage on original cost.

Here the total estimated depreciation is divided by the estimated years of active life of the equipment and the quotient set down as the yearly depreciation charge. This is a method commonly used and is sometimes called the "straight line" method.

2. Percentage on diminishing value.

This method operates on the principle that it is desirable to increase depreciation during the first years when the cost of repairs and renewals is lower. Here a definite percentage is taken each year from the depreciated value of the preceding year.

3. Annual revaluation method.

Here the equipment is appraised at the end of each year. If this be done as a formal appraisal it is apt to be expensive and uncertain, as it is hard to set a true value on going equipment. The results by this method are apt to be no more accurate than the straight line or other methods. In plants where an equipment record or plant ledger card is kept in connection with maintenance work, and on it is carried forward the current yearly value of the piece it represents, such cards form a perpetual inventory and from them it is easy to work up an accurate valuation each year. Such cards should carry not only the depreciated value of the piece but also any increases in value due to permanent improvements which will offset depreciation.

4. Sinking fund method.

Here such a sum is set aside annually and at compound interest will amount by the end of the active life to the original cost of the equipment, less the scrap value.

Full details of the use of these methods, with the arguments for and against them, will be found in any text on accounting or industrial management.

Whatever method is used it must not be forgotten that the purpose of a depreciation account is to allow for wastage and loss of value so that the amount of capital invested may be maintained. In view of this and keeping in mind the changing conditions in the industry it seems less important to be concerned over the method of maintaining this depreciation reserve than it is to write off the equipment as soon as it is reasonably pos-

sible to do so. Could we be certain that the active life of any piece of equipment would be ten years or forty years any system of handling the account would be satisfactory, but as we look back over the past ten years we are likely to wonder whether any method will meet the situation, but at that the oil business is only facing the same conditions of expansion and change which have come to other industries. Large corporations have such great reserves laid aside for various purposes than an unexpected call for almost any sum at most, simply means a transfer from one account to another. The little fellow, however, is not so well situated that he may pour a million dollars down a rat-hole and for him the elusive problem of depreciation has grown from a small ghost which was usually stuck into the cost of a process as an afterthought into real nightmare proportions which must be brought into estimates for new processes as a major consideration.

In the past it has been the custom of many plants to depreciate main items of equipment such as percolation filters, agitators, stills, pumps, etc., over periods of from ten to twenty years even though their active life is much longer than this. Handling depreciation under present conditions simply means that the period over which the equipment must be written off must be shortened in proportion with the probable shortening of its active life. It means that the life of a new installation must be accurately gauged and its salvage value closely estimated. It means that the equipment should be so selected and the layout be made so that the fact of the process itself going out will not necessarily "scrap" the equipment, but will mean a transfer to the new process or to other active service. In this respect an active and effective salvage department can go far in helping cut depreciation costs.

Many changes are forced on the industry by the need of new selling points rather than for any need for striking improvement in the product. One crowd steps out and the others must follow. This, doubtless, is the way of progress but it is hard on the little fellow. When he puts money into a process he must at least be sure of the return of his capital. Recently it has become the practice to require that a new process must show that it can pay for itself in from one to four years. This requirement does seem stiff but it means that greater care must be exercised to work out the kinks and uncertainties in a new process and to stick to conservative design.

OBSOLETE EQUIPMENT LOSS

The only way that obsolete equipment can be charged off is as a loss. But it must be kept in mind that this loss need not be the total original cost of the equipment. It will be the difference between this cost and the salvage value of the equipment. If the apparatus be of some special type which may have no application to other work, or which on salvaging will be unsalable except as scrap, the loss will naturally run higher than would be the case if an effort be made to use standard, well developed equipment. The setting of a short time over which equipment must be written off forces closer estimates of cost and more attention to possible salvage values and this should have a good effect.

A point on which much haziness exists is the relation between maintenance and depreciation. It is sometimes assumed that maintenance and repairs will offset, will take care of depreciation, that it is unnecessary to set up a reserve for the purpose. It is a fact that some repairs, some improvements to equipment do make an increase in value which to some extent offsets depreciation. In general, however, this is not the case. Regardless of how well it has been maintained, the time comes when any piece of equipment must be replaced. With the present conception of a depreciation reserve as a sum set aside to offset the loss of investment, the actual life of equipment does not come into so much consideration as in years past. There are few cases where improvements or repairs justify cutting down the annual depreciation charges. For valuation purposes or in cases where there is a certainty of indefinite use then an increase in value on the books can be considered but it would be well to keep it clear from the regular provision for writing off the equipment. Before any charge of this sort is allowed to be added to the value of equipment it should be scrutinized closely to determine whether it is permanent enough to justify inclusion as a capital value or whether it should be classed as a repair. In the latter case it is of course charged as an item of operating expense. In the oil industry possibly more than in many others we do have cases where depreciation is offset by repair and maintenance charges. In the older practice the refinery was based on shell stills, acid treating and neutralizing agitators, and percolation filters. The principal auxiliaries were tanks, pumps, and piping. With the shell stills the required repairs kept their earning power practically at the value of new equipment. The same was true of agitators, filters, tanks, and piping. A defective sheet or cone was replaced, and provided that there was use for it, and that it did not become obsolete, the equipment would, as the old timers said "last forever." In this way the repairs to a great extent offset depreciation and there was some justification in cutting the annual depreciation charges to a minimum or in not setting aside a depreciation reserve at all. At least there is some excuse if only the going, or producing value is to be considered. If, however, we are to consider the value of the equipment as capital, then we can not possibly put the same value on it as on new equipment. We must consider only its re-sale value or its salvage value for use on other service, at the end of the period when it is to be retired.

DEPRECIATION AND REPAIRS

But why is it not possible to lump the depreciation

charges and repair charges together? When you come down to it both are operating expenses, both cover much the same ground.

A repair represents actual work done and material used within the limits of a given accounting period.

While the work does keep the equipment in operation and to that extent holds up its value, very rarely indeed does a repair add to the value of a piece or can it be considered permanent. It is better, therefore, to consider maintenance as an operating expense and charge it to the accounting period where the work was done.

It will be seen that under modern conditions, if we are to make a definite thing of depreciation it is necessary to get away from the idea that it is provided to cover only the active life of the equipment. As we must consider it now, it does not and for that matter it never did, except in theory. It is simply a sum set aside in yearly installments to cover the cost of replacement of equipment at some later date or to cover its cost when it goes out of service. These installments must naturally come out of earnings just as any other operating costs come out of earnings. The period over which they are to be collected will depend not so much on the actual life of the equipment as it will depend on the company, on its financial strength and policies, and on the process in which the equipment is used. To a corporation with large reserves, the scrapping of a process may mean little. It can afford to spread depreciation returns over a long period. It can even afford to take chances on the process ever paying for itself. With the smaller concern it is important that capital be kept intact, and for that reason it may be necessary to shorten the period over which the depreciation charge is collected. In actual practice, however, it is surprising how often these conditions are reversed. The little fellow, over anxious for dividends, will carry little or no reserve against the time when the equipment loses its earning power, while the billion dollar corporation goes to extremes to determine the life and earnings of a process, carrying all kinds of contingency reserves against loss.

We have brought out the fact that with some processes the equipment is required to pay for itself in from one to four years. This does not mean necessarily that the entire depreciation charge must be taken out during that short period. In most cases this is just a preliminary safety requirement, and once the operation is assured the actual depreciation reserve is taken out over a much longer period.

With some concerns the depreciation charge is set on the basis of wear and tear only, while the uncertainties, such as inadequacy and obsolescence are cared for by so-called contingency reserves. These are more or less general reserves for protection against loss. This would seem an ideal method for handling depreciation and obsolescence as such contingency funds are really a part of the surplus.

In fitting the item of depreciation into the present scheme of things it would seem that the first move should be to alayze the element of risk in the process. Just what are the chances of its being superseded by something new in a comparatively few years? It is in the development stage and will extensive changes throw out the equipment which it is proposed to install? Or is the equipment of such a type as to be flexible in its operation under reasonably wide changes in process conditions and does it have high salvage values?

Where this analysis shows a high element of risk and uncertainty we can only set our depreciation rate high enough to cover the installation cost in as short a time as is reasonably possible. Under such conditions the cost and returns from the process must be closely estimated and the depreciation rate set more with regard to covering the risk than with regard for the actual physical life of the equipment.

Where the analysis indicates few possible changes, fair flexibility, and high salvage value, we may base the depreciation rate more on the actual active life of the equipment than in the foregoing case. The risk of loss due to change and obsolescence being reduced the depreciation charges may be spread over a considerable period and the yearly profit from the process increased accordingly.

From all this it will be seen that depreciation is just another item of operating expense. It is just as necessary to keep this down as it is to lower any other expense item. The place to do this with depreciation is in the original development of the process, in the design and layout of its equipment. While husky build may keep the repair costs low it may or may not affect depreciation. Flexible design, standard equipment with a high salvage value are the things that count on this point. And a careful study must be made to keep the risk of loss at the low limit.

On the other hand, it must be kept in mind that there are times when large returns may justify shorter life in equipment. When a process can be put in, a good profit taken, then the whole proposition closed up and salvaged, there can certainly be no objection.

In any event, whether the process is to pay for itself in one year or in forty years it must be evaluated on every point. Every opportunity for profit must be brought out as well as every chance of loss. Among the items of expense, depreciation must have consideration as a definite thing and not just as a percentage of cost set as an afterthought and based on a guess as to the life of the equipment which it covers. And to make it a definite thing the annual charge must be set only after careful consideration of the probable life of the process, the cost and salvage value of the equipment and the financial policies of the concern making the installation.

Technical Control of

Percolation Filtration

PART 2

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CONTROL OF PLANT FILTER OPERATION

TECHNICAL control of plant filter operation should be a routine matter. It should be based upon definite standards established for the individual stocks by preliminary laboratory investigation. These standards should consider the following factors:

a. Optimum running rate (clay-oil contact time).
b. Optimum temperature of filtration.
c. Operating time schedule.
d. Steam, naphtha and air requirements for washing, together with specified method of washing.

Information on the above could be available in pamphlet form to the foreman in the filter house. Care should be taken to see that full information is recorded on the operating data sheet. Typical forms for filter operation are shown in a recent paper entitled "Percolation Filtration in the Light of Recent Process Developments."[2]

A. RUNNING OF FILTERS

Preliminary to processing a given stock in the plant, a laboratory study should be made to establish the optimum time of contact and temperature of filtration to obtain the desired product quality. Having established the optimum, limitations of plant equipment, such as maximum allowable pressure and temperature, together with consideration of throughput requirements, will in general dictate the nearest approach to the best conditions that can be obtained.

The success of any studies of percolation filtration in the laboratory depends upon close correlation between plant and laboratory results and the reproducibility of results. There are many varieties of individually developed methods for clay evaluation which often lead to false conclusions and are of little value in interpreting laboratory results on the basis of expected plant operation. The following method has proven satisfactory if adhered to exactly:

TEST 3—METHOD FOR EVALUATING CLAYS BY PERCOLATION

Apparatus:

See attached sketch (Figure V).

Standard Charging Stock:

Pennsylvania Cylinder Stock Solution (60 percent safety solvent) N. P. A. color approximately 3¾ Double Dilute.

Procedure:

Charging Clay

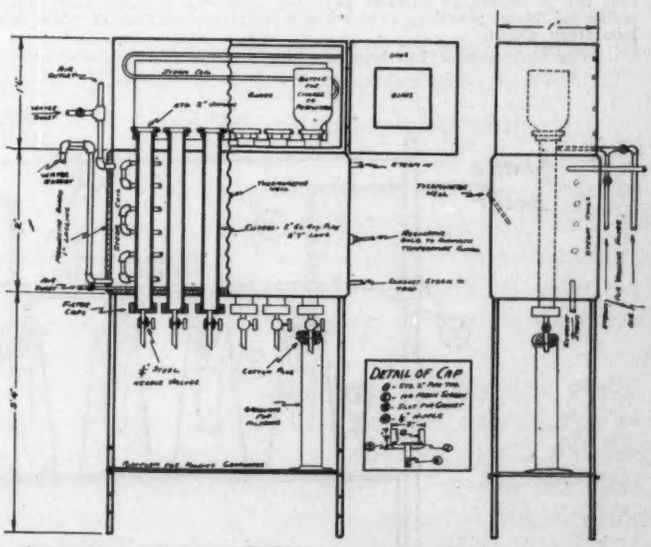
Thoroughly clean filter until a clean cloth swabbed through filter shows no contamination.

Clean cap assembly at base of filter. Inspect and replace, if necessary, gasket and screen. Screw cap on base of filter by hand, using lug wrench to secure tight gasketed joint. Close bottom valve.

*Charge clay in filter to a height of 26 inches as measured from screen at base of filter. The clay should be charged in increments of approximately one third of the total charge. After each increment the clay should be tamped by allowing a rod and rubber stopper tamper to fall freely five times, from the top of the filter onto the top of the clay. The net weight of clay charged to the filter must be carefully noted.

Percolation

Thoroughly shake the stock drum before withdrawing any oil (colors should be recorded on every charge withdrawn from the charge drum). Place the charge in one half gallon bottles and set up in upper compartment of the filter. Bring oil to temperature of the bath.



APPARATUS FOR LABORATORY PERCOLATION DETERMINATIONS

FIGURE 5

Bath temperature should be brought to 135°F. before charging the filters.

Carefully invert bottle over top of filter. Bottle will form its own seal.

Crack valve open on bottom of filter. Note time that oil shows through, also time when bottle inverted. When oil shows through, shut off valve and let filter soak for two minutes, then adjust rate to 15 cc. per minute. Maintain temperature of clay and oil at 135°F. (±0.5°F.) throughout test.

†Take 250 cc. cuts in 250 cc. graduates, obtaining colors on each cut and putting all the filtrate in a composite bottle. Unless otherwise instructed run to composite colors of 3½, 4½ and 6½ N. P. A. ‡Cuts should be taken every 100 cc. or smaller when nearing the composite color.

When the filter is off, remove charge bottle from filter and allow filter to drain. If the clay is not to be revivified, steam until steam shows through, blast with air to dry filter, remove bottom plate and dump clay in pail. Filter should then be washed with naphtha until absolutely clean, then dried and capped.

Standard Method of Running Filters:

Temperature

Pennsylvania cylinder stock solution should be filtered at 350°F. The temperature at which other stocks should be filtered is determined from standard plant practice on the material in question.

Percolation Rate

In comparing different grades of the same clay, for example 15/30, 15/60, 30/60 and 60/90 mesh samples, rate adjustment should be made to insure at least equal time of contact of clay and oil in the percolation test. In the percolation of a specific stock for which optimum operating conditions are not known, the time of contact permitted should approximate as closely as possible standard filter house practice on that material.

It is often found desirable to increase filtering rates in plants with limited filtering capacity and the question is "how?". Where the oil to be filtered is the undiluted stock, this can be accomplished to an appreciable extent by using a coarser mesh clay. It is known that under similar conditions of pressure and temperature, a greatly increased rate of flow can be obtained from the coarser mesh clays than from the finer mesh. However, the yield-rate-temperature relationship is so widely different for various charge stocks on the different meshed clays that requirements should be determined for individual cases. The following grades of percolation clays are readily available on the market:

15/30 Mesh
15/60 Mesh
30/60 Mesh
60/90 Mesh

Laboratory filter yields obtained under the conditions noted under the test (Test 3) can be correlated directly to plant performance. In general, plant filter yields, even under most favorable conditions, are slightly lower than laboratory filter yields.

When the actual plant filter yields are lower than the correlated laboratory yield, this condition is frequently due to channeling. This condition may be overcome by the installation of an inverted loop on the oil outlet of the filter for the purpose of maintaining uniform contact of clay and oil. Application of the "inverted loop" to 20-ton filters has resulted in 5 to 10 percent increase in yield of filtered oil and correspondingly greater increase may be effected in the case of filters with capacity larger than 20 tons.

B. OPERATING TIME SCHEDULE

Definite time standards for filter operation are essential to reduce idle and non-productive time. The standard time for the various operations should be

*This method of charging a fixed volume rather than a fixed weight of clay to the filter has been adopted to agree with actual refinery filter house practice. It eliminates variations in test results due to differences in clay weight, but gives a true evaluation since yields are calculated on a weight basis while actual percolation is carried out on volume basis.

†This procedure of running the filters to a definite composite color rather than determining the color of a specific volume of filtrate has been adopted to eliminate irregularities which result when determining clay efficiency on a variable color removal basis. It has been found that the procedure as outlined herewith represents a more exact duplication of plant practice, permitting a close correlation of plant and laboratory yields.

‡Tag Robinson or Lovibond machine may be used if preferred.

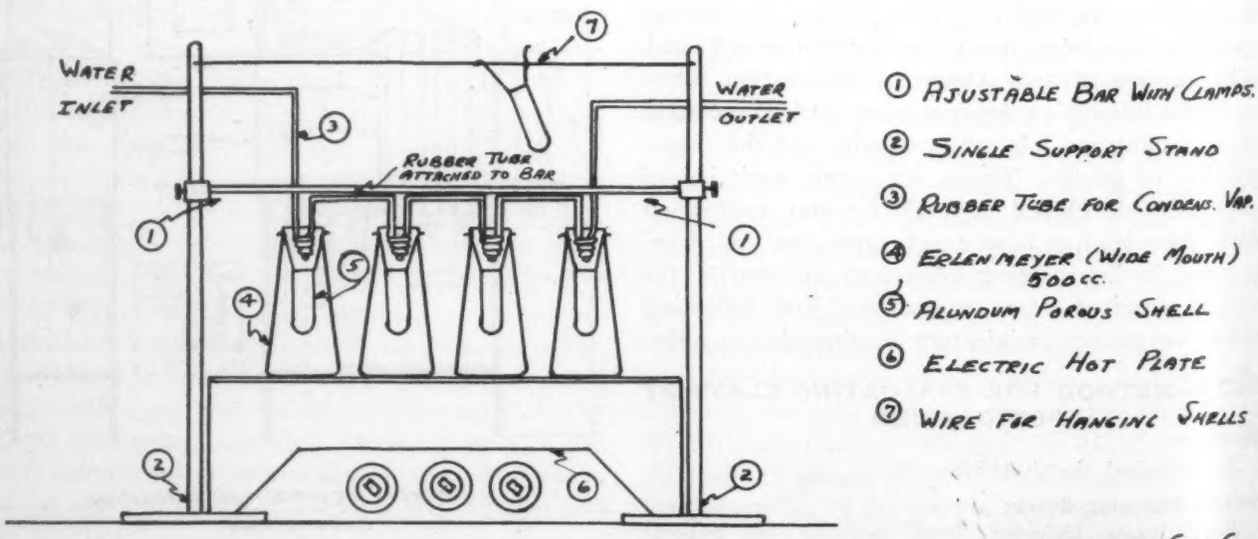

WATER INLET
WATER OUTLET
RUBBER TUBE ATTACHED TO BAR
1 ADJUSTABLE BAR WITH CLAMPS.
2 SINGLE SUPPORT STAND
3 RUBBER TUBE FOR CONDENS. VAP.
4 ERLENMEYER (WIDE MOUTH) 500 CC.
5 ALUNDUM POROUS SHELL
6 ELECTRIC HOT PLATE
7 WIRE FOR HANGING SHELLS
ATTAPULGUS CLAY CO. TECHNICAL DIVISION PHILA. PENNA.

FIGURE 6

established by plant test, and this job is definitely a part of technical control.

C. CONTROL OF PLANT FILTER WASHING

The washing of plant filters with naphtha has as an object the recovery of viscosity oil from the used clay. The proper functioning of the burning operation depends upon reducing the oil content of the used clay to 1 percent or less. Furthermore, the loss of oil through improper washing of filters results in substantial monetary loss. For example, on the basis of a washed filter containing 20 tons of clay testing 3 percent oil, the loss would amount to approximately 160 gallons of stock. Reduction of this oil content to 1 percent would mean a saving of 106 gallons, or, at 8c per gallon, about $8.00 per filter dumped.

It has proven feasible to install a valve on the filter manhead to allow sampling of washed clay before dumping the filter. This sample is analyzed for oil content in the laboratory while the filter is on final steam, so that no operating time is lost. If the oil content of the clay is greater than 1 percent, the filter should be rewashed. A useful method for determination of viscosity oil (not asphalt) in clay follows:

TEST 4—METHOD FOR EXTRACTION OF OIL FROM CLAY

Apparatus:

Extraction shells. Alundum R. A. 98.
Eimer & Amend catalogue No. 22820.
Size 34x100 mm.
Erlenmeyer flasks, wide mouth, 500 cc.
100 cc. beakers.
Hot plate and clay baths.
See attached sketch for details (Figure VI.)

Procedure:

Weigh about 25 grams of clay in the shell. Place the shell in place inside of the flask. Pour 75 cc. of the solvent naphtha, first into the shell up to about half-inch from the top (caution should be taken not to overflow it) and then pour the rest into the bottom of the flask. Heat the flask with the condenser coils in place until the naphtha comes through the shell clear. This can be tested by holding a piece of filter paper under the shell and blowing until dried. No stain should be visible when all the oil is extracted. When doing this, care must be taken not to be misled by the clear naphtha condensing on the outside of the shell. A few seconds therefore should be taken before testing with the filter paper.

When the extraction is complete, the solution is poured into a weighed 100 cc. beaker. Place the beaker on a hot plate and evaporate to a small volume.

The beaker is then transferred to a clay bath kept at about 220°F. over which a stream of air is blown gently to complete the evaporation. When dried the beaker is transferred to a dessicator and weighed.

Results:

Weight of oil $\times$ 4 = percent by weight oil in clay.

Time and Accuracy:

The time required to complete this test varies somewhat with the amount and type of oil present. A heavy oil will take longer to extract than a light one.

Likewise a clay with a small amount of oil will not take as long to be extracted as one with a high percentage.

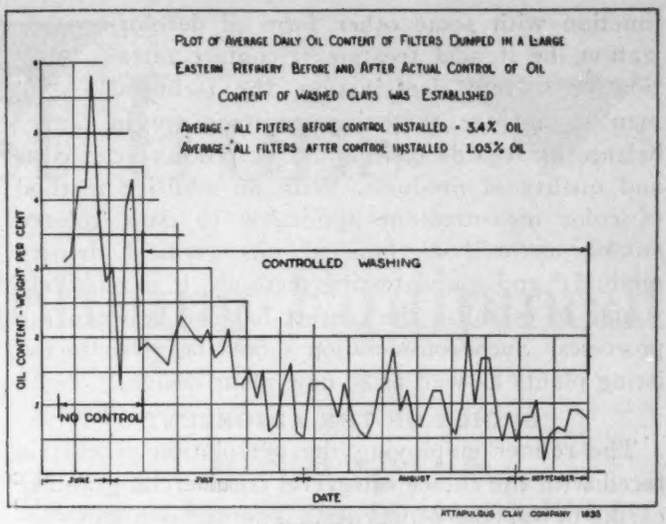

PLOT OF AVERAGE DAILY OIL CONTENT OF FILTERS DUMPED IN A LARGE EASTERN REFINERY BEFORE AND AFTER ACTUAL CONTROL OF OIL CONTENT OF WASHED CLAYS WAS ESTABLISHED
AVERAGE - ALL FILTERS BEFORE CONTROL INSTALLED - 3.4% OIL
AVERAGE - ALL FILTERS AFTER CONTROL INSTALLED 1.05% OIL
CONTROLLED WASHING
NO CONTROL
OIL CONTENT - WEIGHT PER CENT
DATE
JUNE
JULY
AUGUST
SEPTEMBER
ATTAPULGUS CLAY COMPANY 1935

FIGURE 7

In any case, the total time required should not exceed 45 minutes for the complete operation.

The results obtained by this test should check within 0.1 percent of the oil content.

Note:

Solvent naphtha—5 percent distilling at a temperature not below 160° F. nor above 190° F. 95 percent should distill below 220° F. It is within the accuracy of the test when applied to clay to use a filter house or safety solvent naphtha. However, time is sacrificed by using a wide range naphtha.

The use of naphtha for washing filters requires that the steaming operation remove the naphtha from the clay in order to prevent monetary loss, and insure a naphtha-free clay that will not be a fire hazard in the conveyor system, nor cause "wild fires" in the furnace on burning with resultant fusion of clay and destruction of equipment. A sampling condenser on the steam-out line has proven a practical method of determining the naphtha content of the "steamings" and is a more accurate control than the average operator's sense of smell.

An idea of the extent to which oil content of clay may be reduced is shown in Figure VII depicting operating results before and after applying technical control to filter washing in a plant demonstration.

D. POINT OF CLAY DISCARD

Clay should, of course, be discarded from the system when its re-use results in an increase of cost of the oil product. Laboratory evaluations should be made of composites of each number clay burned during the month, and cost calculations based upon the filtering efficiencies obtained to determine the point of discard.

In addition to the foregoing evaluation, a percolation determination should be made on any clay of abnormally high volume weight and normal volatile content for the purpose of ascertaining whether filter yields are below the economic point established for discarding. Such a clay cannot be brought back in efficiency and is worse than valueless.

A schedule of control tests and an approximate schedule of their application is shown in Figure VIII.

Where the percolation process operates in con-

junction with some other form of decolorization, be it acid treatment, contact filtration or solvent deresination, the technical man should see that the processes are in balance as regards distribution of process load, costs and quality of products. With an additive method of color measurement applicable to dark colored stocks, as well as finished oils (optical density method)[3] and sound testing methods, it is relatively simple to establish the correct balance between the processes. Such consideration should be given to existing plants as well as to new plant design.

CHOICE OF THE ADSORBENT

The refiner employing the percolation process is faced with the choice of several commercial granular earths of varying properties. The decision as to selection of an adsorbent should be made on the basis of true worth in the refining process and not on the basis of the first cost. Inattention to this consideration has sometimes led to excessive filtering costs through the selection of an inferior material.

The following characteristics of the several earths should be determined:

a. Initial percolation efficiency.
b. Efficiency on revivification.
c. Characteristics of the earth in the washing and steaming operation.
d. Volume weight relationship.

Relative values for the above items can be secured in the laboratory and should narrow the selection. It is usually wiser to accomplish the final ratings on plant scale operation, due to the fact that greater differences on revivification will obtain in the plant because of more severe burning conditions. All evaluations of plant burned clays should be made in the laboratory under controlled conditions, since plant charging stock variance is apt to confuse the picture.

Comparison of competitive clays should be made on samples of the same mesh size. Yields should be calculated on a clay weight basis and percolation evaluation should be made with equal volumes and filter height of clay.

A detailed cost analysis similar to the method described in "Percolation Filtration in the Light of Recent Process Developments"[2] should be made in order to determine the cost of percolation filtration with the various clays. This cost analysis should then be accepted as the sole basis for choice.

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FIGURE VIII

Schedule of Technical Control Test and Comparisons with Standards

	Volatile Matter Percent	Volume Weight Lbs./Cu. Ft.	Oil Content Percent	Percolation Efficiency Percent	Standards Comparison		Oil Inspections Color, Vis., Grav., Water—% Solvent
					Time	Quantity	
INSPECTIONS							
Clays							
Hourly from burners	Hourly	Hourly	.....	.....	....	.....	.....
Sampling valve on filter before dumping	.....	.....	As Washed	.....	....	.....	.....
Monthly composites of each number burned clays of high weight	Monthly As Required	Monthly As Required	....	Monthly As Required	....	....	....
Oil							
Composite of charge stock	.....	.....	.....	.....	....	.....	Daily
Composite of filtered oil	.....	.....	.....	.....	....	.....	Daily
STANDARDS COMPARISON							
Clay Burning							
Fuel	.....	.....	.....	.....	....	Weekly	.....
Steam	.....	.....	.....	.....	....	Weekly	.....
Operating time	.....	.....	.....	.....	Daily	.....	.....
Non-Operating time	.....	.....	.....	.....	Daily	.....	.....
Thruput	.....	.....	.....	.....	Daily	.....	.....
Filtering							
Yields	.....	.....	.....	.....	....	Daily	.....
Steam-pumping & heating	.....	.....	.....	.....	....	Weekly	.....
Steam-washing	.....	.....	.....	.....	....	Weekly	.....
Naphtha-washing	.....	.....	.....	.....	....	Weekly	.....
Air-washing	.....	.....	.....	.....	....	Weekly	.....
Operating time	.....	.....	.....	.....	Daily	.....	.....
Idle time	.....	.....	.....	.....	Daily	.....	.....
Thruput	.....	.....	.....	.....	....	Daily	.....
Cost calculations on optimum point of clay discardal	.....	.....	.....	At least every 6 mos. & as process or stock changes			.....

Attapulgus Clay Co. 1935

Alloyed Cast Irons

In Petroleum Refining Equipment

J. S. VANICK

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A GREAT deal of progress has been made in the last ten years in the quality and properties of cast iron, and the petroleum refining industry has been quick to use or seek to employ these improvements to the fullest extent in step with the progress in its own field and the demands upon its production departments for economy and efficiency. This does not mean that the output of the gray iron shops has suddenly swung completely to a product of a high order of excellence any more than that the output of the oil refinery has swung completely to premium gasolines. A great deal of plain cast iron is still produced and the modest 20,000 pounds per square inch strength, requiring no appreciable degree of pressure tightness, can be secured without much concern on the part of either producer or consumer. The broad range of properties available in modern cast iron—such as a strength of 20,000 to 60,000 pounds per square inch, or up to 80,000-100,000 pounds per square inch, when heat-treated, and a range of hardness from 100 to 500 Brinell, with other physical properties improving correspondingly—gives the equipment manufacturer or refinery constructor an opportunity to build up to the new properties now being obtained. In addition these properties are available in high grade cast iron at a moderate or no increase in cost for the reason that raw materials needed do not vary appreciably in cost and alloys deliver more value per dollar when employed in castings than when used in wrought shapes. Sometimes it is possible to improve a poor or average grade of iron by alloying it directly and depending upon the alloys to correct inequalities in the base composition. Nickel, chromium, and molybdenum, singly or grouped, can be applied in unbalanced proportions to bring an unbalanced cast iron into a compositional equilibrium and at the

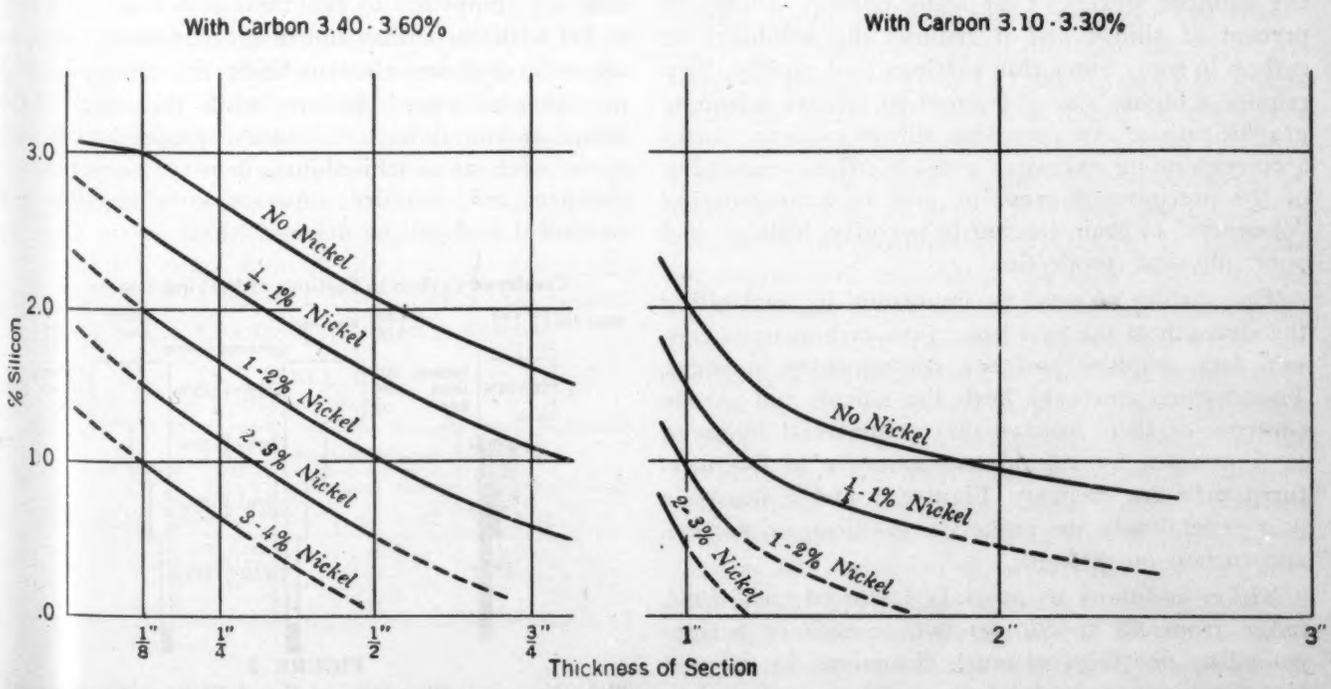


FIGURE 1

Percentages of Silicon and Nickel Required to Render Castings of Different Section Completely Gray and Machinable.

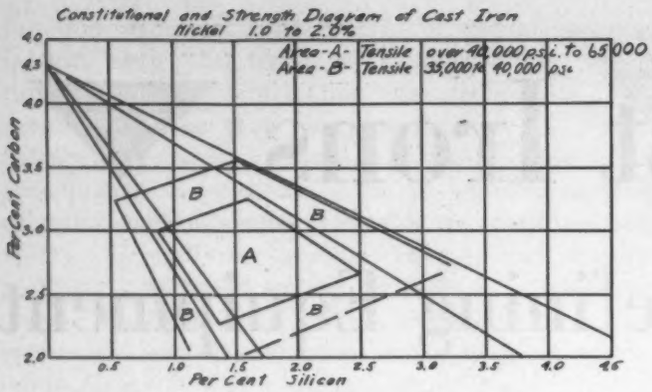

Constitutional and Strength Diagram of Cast Iron
Nickel 1.0 to 2.0%
Area-A- Tensile over 40,000 p.s.i. to 65,000
Area-B- Tensile 35,000 to 40,000 p.s.i.
Per Cent Carbon
Per Cent Silicon
A
B

FIGURE 2

same time impose some of their influence upon the resulting product. A better and more economical procedure which is customarily followed in steel making, consists of first producing the best possible base composition, then adding the alloys—properly balanced—to do their bit. Unfortunately, cast iron and steel cannot be treated in the same way, and the same proportions of alloys used for one as for the other. One exception, if there may be one, is in the nickel alloyed irons simply for the reason that nickel acts largely upon the iron component instead of the carbon of the complex iron-carbon-silicon combination that constitutes cast iron. An effort to outline the action of important chemical elements composing cast iron, is made as follows: Most important is carbon, which is present in commercial cast iron from 2.50 to 3.50 percent. In a gray cast iron of the usual type, at least two-thirds of its carbon is desired in the form of graphite. This graphite content would not be present if it were not for the action of the element silicon. Cast irons contain .50 to 3.0 percent of silicon and it reduces the solubility of carbon in iron. Since thin castings cool rapidly, they require a higher silicon content to achieve adequate graphitization. An excessive silicon content causes a corresponding excessive graphitization, coarsening of the precipitated graphite, and an accompanying "openness" of grain leading to porosity, leakage, and poor physical properties.

The carbon content is important in controlling the strength of the cast iron. Low-carbon irons contain less graphite and are consequently stronger. Foundrymen can vary both the silicon and carbon contents of their irons within commercial limits of ± 5 percent, by suitable adjustments of the mixtures they are melting. Figures 1 and 2 illustrate in a general way the influence of silicon on section, and carbon on strength.

Nickel additions to properly balanced cast irons, range from .25 to 5.0 percent, sometimes accompanied by one third as much chromium, i.e. from .1 to 1.5 percent, or molybdenum replacing chromium when desirable to avoid embrittlement or reduce machining troubles. In special cases, as in the corrosion resisting cast iron, nickel additions up to 20 percent may be employed and where low or high expansivity is needed, up to 40 percent may be employed. It is worth mentioning at this point that foundrymen have mastered the production of these highly alloyed irons without recourse to the use of special melting equipment.

Alloying elements are classified as graphitizing types or carbide-forming types, depending upon whether they promote the action of silicon in precipitating graphite from the iron-carbon solution or oppose this effect and form carbides. There seems to be no neutral position and any element inactive in this iron-carbon system is likely to be considered inert and of little significance in affecting the important physical properties of cast iron. Of the three most important alloying elements, nickel, chromium and molybdenum, nickel is a graphitizer; chromium and molybdenum, carbide formers. The intensity of their respective effects may vary within the carbon-silicon ranges outlined above. Thus, one part of nickel possesses approximately the force of 2/5 to 1/3 parts of silicon as a carbide destroyer. Chromium resists silicon upon a point-to-point basis. Molybdenum is somewhat less powerful than chromium as a carbide former. These alloys after being balanced to maintain equilibrium as regards graphitizing power, begin to exert their important secondary effects upon the iron-carbon-silicon solution by strengthening, hardening, toughening, etc. A perfectly balanced plain cast iron makes an excellent base to build from. If nickel alone is to be added, it would be desirable to reduce silicon or carbon to maintain a proper balance. In some cases, foundrymen are compelled to run their soft irons and then nickel with chromium and/or molybdenum additions are necessary, one element being the complement of the other as regards balance while the effect of the alloys is cumulative. Collateral properties of cast irons, such as machinability density, corrosion resistance, etc., require separate consideration and treatment and will be discussed first.

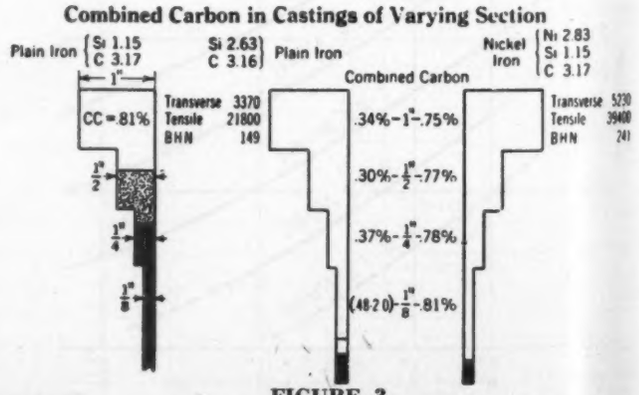


FIGURE 3

Plain Iron and Alloy Iron of Equal Chilling Tendency and of Approximately Equal Machinability in Castings of Varying Thickness.

MACHINABILITY

Machinability, grain refinement, density, uniformity, are undefinable, yet important properties of castings. All these are interrelated. Usually 0.5 to 2 percent of nickel is used to develop them. As mentioned above, nickel exerts a graphitizing effect similar to silicon, but unlike silicon which may completely free an iron of combined carbon, it exerts a greater solvent power for carbon. Dissolved carbon must be diffused and not allowed to concentrate into lumps or colonies of carbides. Pure nickel will dissolve carbon while silicon may not, and the presence of as little as three percent silicon in iron almost completely destroys the solid solubility of carbon in iron. Since much of the body and strength of an iron and the effect of alloys upon it, depend upon the presence of dissolved carbon in it, nickel exerts a positive but restrained influence in compelling complete graphitization of carbide residues yet relinquishing its graphitizing power as soon as this lumped carbon is diffused and in solution. The step bar casting offers a practical means of illustrating these principles. Figure 3. An iron correctly balanced for the ½-inch section will be coarser grained than desirable in the two-inch section and ungraphitized and unmachinable in the ¼-inch section, as well as unmachinable along the edges of the ½-inch and thinner sections, because the effective section through the corner is approximately equal to half the flat section. Thus the radius through the corner of the ¼-inch section is approximately equivalent to a round bar ⅛-inch in diameter.

If the nominating section of the casting is ½-inch thick and requires 2.0 percent silicon with 3.30 total carbon, then the ⅛-inch section should contain at least 2.75 silicon. Since this silicon would promote a coarse grain and openness possibly leakage in the ½-inch and larger sections, the corrective of applying 1.5 percent nickel to the two percent silicon iron maintains the close grain of this composition for the ½-inch or larger sections and produces the necessary graphitization in the ¼-inch and ⅛-inch sections to promote rapid machinability. For example, piston rings, individually cast, are frequently made 3/16-inch to one-inch thick with a two percent silicon iron and two to ¾ percent nickel, viz:

TABLE I
Piston Rings

Plain Iron Well Balanced	Plain Iron Poorly Balanced	Section, Alloyed to Densen—and Machine Well			Alloy Hardened*		
		3/16"	½"	1"	3/16"	½"	1"
T. C..... 3.20–3.50	3.30–3.50	....	....	....	....	....	....
Si..... 1.80–2.20	2.40–2.70	....	....	....	....	....	....
Ni.....	.....	1.50	1.0	.60	2.0	1.50	1.0
Cr.....	.....	....	....	....	.30	.30	.30

*Hardened to resist wear.

In another case, grease gun cylinders, expected to machine at high speeds, thread ends, finish smooth,

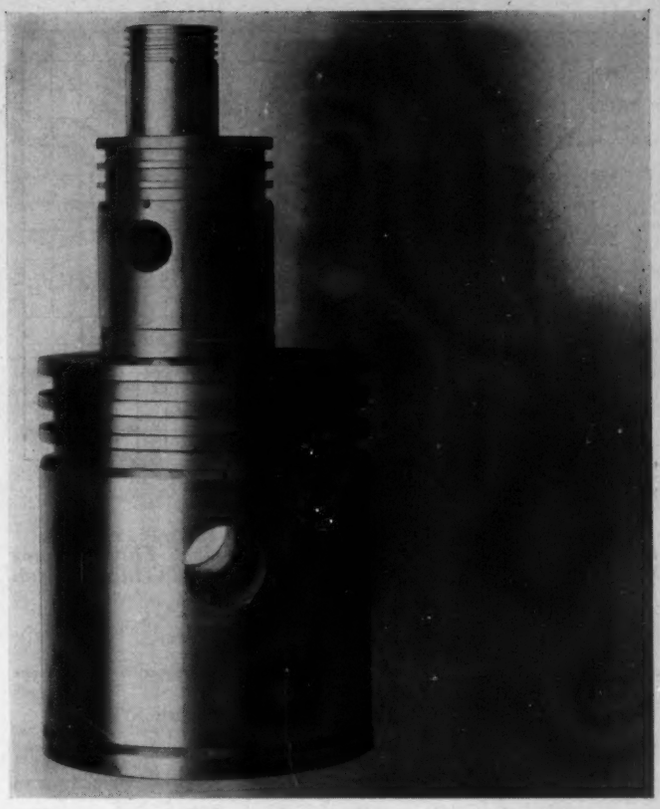


FIGURE 4.
Nickel Cast Iron Pistons.

with sections ¼-inch to one-inch in the casting, were made of a base mix similar to the above with one to 1.5 percent nickel to maintain the close grain, pressure tightness, and machinability required of this exacting, production job.

DENSITY—PRESSURE TIGHTNESS

Pistons for reciprocating pumps, engines, and compressors, represent another common problem in obtaining dense, pressure tight castings. The following description and outline, illustrate the case. Automotive pistons (Figure 4) always light in section along the skirt and heavy sectioned in the piston pin boss, have a characteristic habit of revealing porosity in the neighborhood of the bosses, or between the head and boss. The condition is not discovered until considerable machining is done and the casting skin removed or the shrink spots reached when the ring grooves are cut. The soft iron needed to keep the skirt machinable opens the grain and encourages shrinkage in the heavy sections. A reduction in silicon content of .1 to .3 percent readily achieved by using a corresponding quantity of low (.3 or less) silicon steel scrap in the change promotes a tightening of the grain, while a nickel addition, equal to double the amount of the silicon removed, restores the necessary structure and machinability. Where foundry mixtures cannot be changed, nickel-chromium additions slightly out of balance, but certain to maintain machinability at a somewhat reduced rate due to the accompanying hardening effect, can be applied, viz:

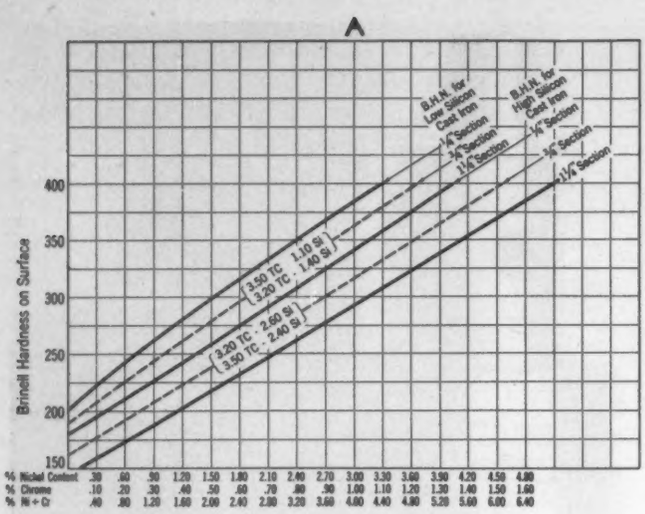


FIGURE 5

Hardening thin sections by direct alloying. Thin sections ¼" to 1¼" (1) low silicon cast iron, (2) high silicon cast iron.

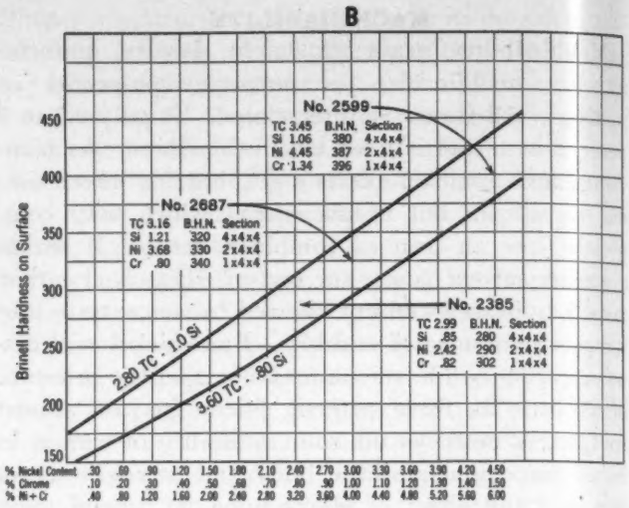


FIGURE 6

Hardening thick sections by direct alloying. Heavy sections up to 4 inches. (1) low carbon cast iron, (2) high carbon cast iron.

TABLE II

Plain Iron	Skirt—Section With Nickel			With NI—CR		
	Light ⅜"	Medium 1"	Heavy 1½"	Light ⅜"	Medium 1"	Heavy 1½"
T. C..... 3.10–3.40	....	....	....	....	....	....
Si..... 2.20–2.40	2.20	1.90	1.40	2.40	2.40	2.40
Ni.....	.75	1.25	2.0	.75	1.25	1.50
Cr.....	....	....	....	.30	.50	.60
Approximate Strength.....	30,000	35,000	38,000	30,000	35,000	40,000
Hardness.....	160	175	190	175	190	210

WEAR RESISTANCE

The preceding table illustrates in general the manner in which hardening is accomplished. Hardness may not be synonymous with wear-resistance if microstructure is ignored, but hardening an iron by preserving its basically good structural qualities and building up hardness by means of balanced additions of alloys, as illustrated above (Table II), has repeatedly demonstrated an ability to resist wear. It might be interesting to add that these correctly balanced alloyed, cast irons, are not only hardened, but strengthened and toughened as well. A good wearing machinable hardness of 200 to 280 BHN in the "as cast" condition can be selected from an inspection of Figures 5 and 6. Pump liners, valve parts, engine and compressor castings (Figure 7), are typical refinery castings treated in this way.

Results of wear tests[1] made in the working parts of pumps, illustrate in the following data, the practical application of the principles described:

TABLE III

	T.C.	Si.	Ni.	Cr.	BHN	Wear—Weight Loss, Mg. Per Sq. In., After 20 Hrs.
Plain....	3.40	2.20	....	....	170	75
Alloy....	3.42	2.28	1.23	.21	200	35

[1]Huss-Viking Pump Co., "Long Wearing Irons Extend Pump Life," Nickel Cast Iron News, 3, No. 4 (Oct. 1932) pp. 6-7.
[2]Proc. A. S. T. M. 29, Part II, 167-8 (1929).
[3]Proceedings A. S. T. M. 32, Part I, 625 (1932); 1932 Book of A. S. T. M., Tentative Standards, p. 179.

Similar evidence has been presented by Bornstein[2] from operating tests on tractor-engine cylinders. Nickel-chromium-alloy-iron cylinders containing 0.68 percent of nickel and 0.22 percent of chromium were 26 points higher in Brinell hardness and showed only 68 percent of the wear of plain cast-iron cylinders.

HEAT TREATMENT

Some castings, such as pump and engine liners, cam shafts, etc., are heat-treated either to develop strength or hardness for resistance to wear (Figure 8). Castings may be softened by an annealing at 1100-1300°F., after which they are rough machined at a hardness of 170 to 220 Brinell. They are then gradually heated to 1450-1550°F., oil quenched to a maximum hardness, after which they are tempered and toughened by heating to some temperature between 400° and 1000°F. The procedure is limited to simple and symmetrical shapes. Cored out castings or complicated shapes are too susceptible to warpage and cracking to be heat-treated. They are best strengthened or hardened by the direct alloying procedure described in Figure 5 and 6 and Table II.

TENSILE STRENGTH

The strength commercially obtainable in gray iron has gradually and consistently been moved up from a 20,000 to 30,000 psi. level to as high as 50,000 to 60,000 psi. Most of the common cast irons today are produced in the 25,000 to 35,000 psi. tensile range but where strengths are important the upper levels have been developed without much difficulty. In special cases, cast irons possessing strength exceeding 65,000 psi. and heat-treated grades up to 100,000 psi. are being made. (Table IV).

The American Society for Testing Materials in 1932 issued A. S. T. M. Tentative Specifications for Gray Iron Castings (A 48-32T)[3] including castings

for high strength applications. The data of Table V are abstracted therefrom. Alloys are almost indispensable to the everyday production of high strength irons. One of the outstanding characteristics of nickel alloyed irons is their ability to level off irregularities in production conditions such as occur due to minor shifts in composition, pouring temperatures, shake-out and cooling conditions, etc., which may adversely affect the strength of ordinary cast irons.

TABLE IV
Effect of Quench and Drawback upon the Tensile Strength of High Strength Nickel Cast Iron

Specimen	Total Carbon, %	Composition		Tensile Strength in Lbs./In.		
		Silicon, %	Nickel, %	Original as Cast	Quenched Oil 1500° F. Drawn at 600° F.	Quenched Oil 1500° F. Drawn at 800° F.
No. 1	2.46	1.98	2.44	59,300	84,700	88,320
No. 2	2.84	1.98	1.44	55.600	75,560	78,840
No. 3	2.78	1.79	2.28	68,000	84,600	84,240
No. 4	2.89	2.02	2.44	66,200	75,560	78.840
No. 5	2.68	2.26	2.69	64,200	72,000	73,400
No. 6	2.81	2.02	3.08	69,606	63,200	82,100
No. 7	2.56	3.06	3.14	60,100	69,200	75,960

Piwowarski[4] in a recent paper, describes these effects thoroughly, and emphasizes the effectiveness of nickel with chromium or molybdenum in obtaining uniformity and reproducibility in high grade cast irons.

TABLE V
Classifications of Cast Iron, from A.S.T.M Tentative Specifications A 48-32 T.

Class	Min. Tens. Strength, psi.	Transverse Strength, Lb. Load for 1.2 In. Bar x 18″ Span
20	20,000	1,700
25	25,000	1,900
30	30,000	2,100
35	35,000	2,300
40	40,000	2,500
50	50,000	2,800
60	60,000	3,100

[4]A. F. A.—reprint 1934—Title, Consistency As a Basis for the Production of High Test Gray Iron.

The class 40 and 50 range of properties is met easily by nickel and nickel-chromium cast irons as is evidenced by the data of Table VI, taken from a technical bulletin of the International Nickel Company. The transverse strength minima of Table V are none too well established and tensile tests are recommended if tensile properties are important.

Class 60 specification or better is met readily in nickel alloyed gray cast irons through the agency of special melting involving the use of over 60 percent of steel in the cupola. This type of iron has been trade named "Ni-Tensyliron." A great many foundries are producing it to meet the 50,000 psi. specification and several are bettering the 60,000 psi. specification regularly. By special heat treatment higher strengths than those cited are obtainable.

The composition of Ni-Tensyliron may be varied over a fairly wide range to accommodate varying sizes and thickness of castings. The general range is given in Table VII.

TABLE VII
Composition of Ni-Tensyliron

Total Carbon	2.50—3.15%
Manganese	0.50—0.90%
Phosphorus	0.15% Max.
Sulfur	0.12% Max.
Silicon	1.20—2.75%
Nickel	1.00—4.00%
Chromium or Molybdenum	0.0 — .50%

TABLE VIII
Physical Properties of Ni-tensyliron.

Transverse breaking load[1]	4,500 to 8,000 lbs.
Deflection	0.11 to 0.25 inch
Tensile strength (arbitration bars[1])	50,000 psi. to 75,000 psi.
Compressive strength	165,000 psi. to 190,000 psi.
Elastic Modulus (tension and compression[2])	20,000,000 psi. to 23,000,000 psi.
Brinell hardness[3]	220 to 320
Fatigue limit	50% to 57% of tensile strength

[1] 1¼″round—12″ centers.
[2] Up to proportional limit.
[3] Particular value obtainable depends upon silicon and nickel content.

FIGURE 7
Nickel Cast Iron Cylinder Heads and Piston used in gas engine.

TABLE VI
High Test Alloy Cast Iron.
Tensile Strength 40,000 p.s.i. to 48,000 p.s.i.

Column	1	2	3	4	5	6	7	8	9	10	11	12
Section	¼" to ½"	¼" to ½"	¼" to ½"	½" to 1"	½" to 1"	½" to 1"	1" to 2"	1" to 2"	1" to 2"	2" to 4"	2" to 4"	2" to 4"
Brinell Hardness	180	220	260	180	220	260	180	220	260	180	220	260
Machinability	Readily	Good	Economically	Readily	Good	Economically	Readily	Good	Economically	Readily	Good	Economically
Wear Resistance	Good	Very Good	Excellent	Good	Very Good	Excellent	Good	Very Good	Excellent	Good	Very Good	Excellent
Total Carbon	3.20-3.40	3.10-3.30	3.00-3.20	3.10-3.30	2.90-3.10	2.80-3.00	3.00-3.20	2.90-3.10	2.80-3.00	2.90-3.10	2.80-3.00	2.70-2.90
Manganese	0.55-0.75	0.55-0.75	0.55-0.75	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95	0.75-0.95
Silicon	1.60-1.80	1.40-1.60	1.20-1.40	1.20-1.40	1.10-1.30	1.00-1.20	1.00-1.20	1.00-1.20	0.90-1.10	0.90-1.10	0.80-1.00	0.70-0.90
Nickel	1.25	1.25	2.00	1.25	1.75	1.75	1.25	1.75	1.75	1.25	2.00	2.00
Chromium	None	None	None	None	None	0.25-0.35	None	None	0.25-0.35	0.25-0.35	0.35-0.45	0.50-0.60

Note:—The harder compositions attain top strength more easily, but machine less freely.

TABLE IX
Properties of Cast Irons.

Property	Plain Iron	High Test Iron	NI-TENSYLIRON A	NI-TENSYLIRON B	NI-TENSYLIRON C
Total Carbon	3.25	2.95	2.60	2.70	2.92
Silicon	1.40	1.00	1.57	1.71	1.45
Nickel	None	1.10	1.34	2.42	4.01
Tensile strength 4" round psi.:					
Outside	29,000	41,800	59,000	68,600	55,000
Center	16,150	31,400	45,600	48,200	42,200

In some cases slightly higher strengths are obtained, particularly in heavy sections, with additions of 0.35 to 0.50 percent of either chromium or molybdenum.

The full ranges of properties obtainable in irons of this class are given in Table VIII. The relation between composition and strength ranges is outlined in Figure 9.

The uniformity of Ni-Tensyliron in heavy sections is shown by the data of Table IX, which is due to MacPherran[5] who has shown that the Brinell hardness of plain gray iron varies from 22 to 30 points from the outside to the center of four-inch rounds,

[5]R. S. McPherran, Proc. A. S. T. M. 29, Part II (1929).
[6]Proc. A.S.T.M.-29, Part II, 1929.

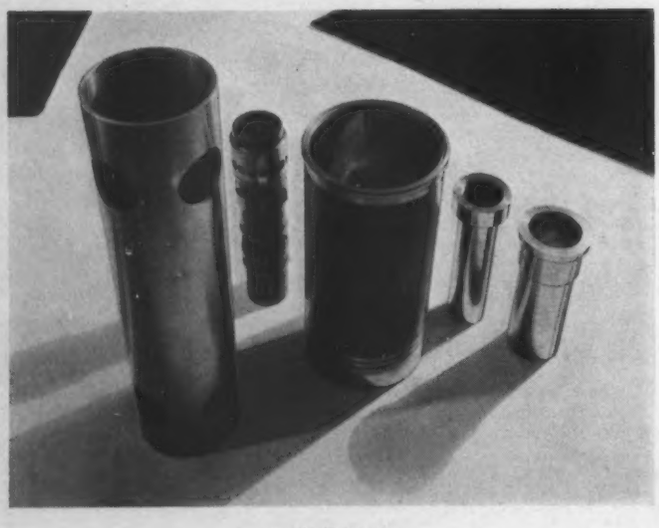


FIGURE 8
Centrifugal Alloy Iron Liners.

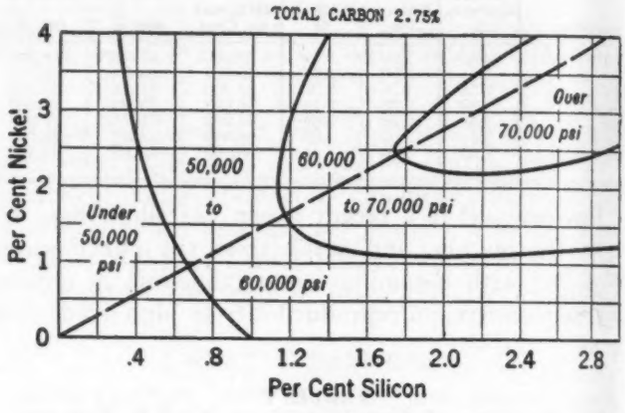


FIGURE 9
Proportions of Nickel and Silicon to get various ranges of tensile strength in sections from ½" to 4" thick.

whereas high strength nickel cast iron was uniformly hard throughout similar sections. The strength throughout the heavy section is well maintained while the strength of ordinary cast iron may decrease 50 percent or more in the core of heavy sections.

The Ni-tensyl type of cast iron finds application for pumps, compressors, engines, valves and other pressure castings subject to considerable load.

IMPACT RESISTANCE

Some cast iron applications such as valve, pump, plug cock and compressor parts, require more than an ordinary degree of toughness. Curiously enough, the high strength alloy irons of the Ni-Tensyliron type generally possess a high deflection and resist impact well. Frequently the impact strength of the Ni-Tensyliron types will be two or three times better than that of the plain irons. The impact test committee of the A. S. T. M.[6] reporting upon some 30 tests in which a plain and nickel-alloyed cast iron were included, compared various cast irons by dropping a 100-pound weight from successively higher levels on a four-inch span of a 1.20-inch diameter bar. The results follow:

	Tensile Strength	Drop—Inches	Average
Plain Cast Iron.....	33,500	6 to 10	7.2
Ni-Tensyliron.....	61,600	11 to 20	16.2

Additional data appear in Table X.

LOW TEMPERATURE IMPACT

Some operations have been conducted at temperatures reaching -50° F. Many materials become brittle at these temperatures and while cast iron is not affected to the same degree as steels, it loses some toughness. The nickel alloyed high test and Ni-Tensyliron types not only possess better impact resistance at normal temperatures but retain more of their toughness at low temperatures. Table X. This result is interpreted by building cast iron equipment which operates successfully at normal temperatures of alloyed, high test nickel cast iron, or Ni-Tensyliron

TABLE X
Low Temperature Impact Properties of Alloyed and Plain Cast Iron

	T.C.	Si.	Ni.	Cr.	Cu.	Foot Pounds[3] Room Temp.	Foot Pounds[3] —45° F.
Plain C. I.....	3.44	1.96	.....	.....	.....	39	29
Nickel C. I.[1].....	2.76	2.02	1.75	.....	.....	44	38
Ni-Resist C. I....	2.73	1.59	13.76	1.95	6.0	55[2]	50
Invar C. I.....	2.50	1.40	30.00	4.00	.....	81	70

[1] High Test Type (develops up to 60 ft. lbs.).
[2] Values as high as 70 ft. lbs. have been developed in softer grades.
[3] Bar 1.20" dia. x 6"—broken "as cast".

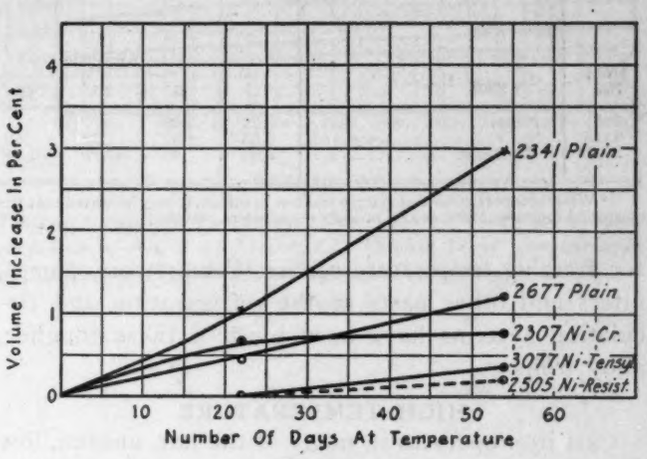


FIGURE 10
Plain cast iron of 2 percent silicon showed greatest growth when subjected to steam at 900° F. A nickel-copper- Chromium cast iron showed the least.

TABLE XI
Stability of Cast Iron at 1000° F. Composition—Percent

Material	Total Carbon	Silicon	Nickel	Chromium
Plain iron.....	3.44	1.96	....	....
Nickel-chromium iron.	3.41	1.97	1.73	0.60

Volume Increase After Indicated Hours—Percent

Material	72 Hr.	185 Hr.	303 Hr.	422 Hr.	542 Hr.	662 Hr.
Plain iron.....	2.16	2.97	3.74	3.86	4.12	4.17
Nickel-chromium-iron.....	0.68	1.06	1.57	1.57	1.78	1.82

Brinell Hardness After Indicated Number of Hours

Material	Start	113 Hr.	231 Hr.	350 Hr.	422 Hr.	542 Hr.	662 Hr.
Plain iron.....	179	103	95	102	105	89	101
Nickel-chromium-iron.....	217	179	163	168	165	156	156

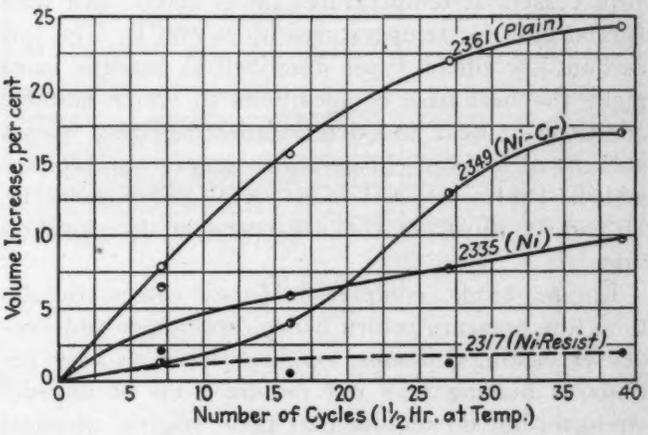


FIGURE 11
Resistance to growth in an oxidizing atmosphere of carbon dioxide at 1500° F.

TABLE XII
Growth of Cast Iron in Steam at 900 Deg. F.

Heat No.	TYPE	Analysis TC	Si	Ni	Cr	Cu	Volume Increase in Per Cent After Indicated Number of Days 22	54	Original	Tensile Strength Lbs. Per Sq. In. After 22 Days	After 54 Days
2341	Plain.....	3.48	2.02	.....	.....	.....	1.01	2.99	18,400	13,840	10,600
2677	Plain.....	3.36	0.82	.....	.....	.....	0.45	1.22	32,900	32,840	27,200
2307	Nickel-Chromium.....	3.04	1.39	0.96	0.33	.....	0.68	0.78	43,000	39,720	41,300
3077	"Ni-Tensyliron".....	2.89	2.45	1.45	.....	.....	0.00	0.36	47,000	54,760	55,200
2505	"Ni-Resist".....	3.04	1.64	13.63	3.23	6.48	0.00	0.23	24,050	27,720	28,400

TABLE XIII
Growth of Cast Iron in an Oxidizing (CO_2) Atmosphere at 1500 Deg. F. (815 Deg. C.)

Heat No.	TYPE	Analysis TC	Si	Ni	Cr	Cu	Volume Increase After Indicated Number of Cycles—Per Cent 7	16	27	39
2361	Plain Cast Iron.....	3.26	2.02	....	....	....	7.87	15.62	22.08	24.39
2349	Nickel-Chromium.....	3.43	1.08	2.33	.49	.....	1.36	3.96	12.59	17.10
2335	Nickel Cast Iron.....	3.82	0.45	3.97	.....	.....	6.54	5.99	7.62	9.76
2317	"Ni-Resist".....	2.88	1.72	14.31	3.92	5.37	2.17	0.59	1.30	1.99

TABLE XIV

Scaling of Cast Iron in an Oxidizing Atmosphere at 1500 Deg. F. (815 Deg. C.)

Heat No.	TYPE	Analysis					Original Weight of Specimen In gms	Grams of Scale Formed After Indicated No. of Cycles			Cumulative Scale Formed Per Cent of Orig. Wt. of Specimen		
		TC	Si	Ni	Cr	Cu		12	28	44	12	28	44
2361	Plain	3.26	2.02	....	....	....	115.49	9.81	29.36	41.24	8.50	25.4	36.6
2343	Ni-Cr	3.53	1.97	1.52	.40	....	114.13	5.98	18.45	33.61	5.25	16.15	29.5
2327*	"Ni-Resist"	2.60	.48	13.17	1.48	6.50	122.49	1.83	9.22	9.73	1.50	7.56	7.95

* While this particular test sample was low in silicon, it may be stated that the standard 1-2 per cent Si Ni-Resist composition is more satisfactory in that it requires no special foundry mixtures and produces equivalent results.

for freezing temperature service. Compressors, pumps, filters and other parts of the refrigeration and circulation systems have been built of these tougher, alloy irons.

HIGH TEMPERATURE

Cast iron operates in many of the hot, unfired, low pressure applications under the traditional limit of 450°F. set by several engineering committees. If specifications limiting the degree of growth are not set which include an outline of a suitable acceptable composition range, the 450°F. temperature limit would better be retained. However, cast irons are available which can be employed for unfired pressure vessels at temperatures up to 700°F. and with special care for temperatures up to 900°F. The low carbon, low silicon types described as pearlitic irons make the best base compositions to which suitable additions of heat and deterioration resisting alloys, such as nickel and chromium in proper balance, are added. Tables XI, XII, XIII, XIV and Figures 10, 11 and 12 illustrate the difference in deterioration rate.

Engine heads, compressor parts, valves, regulators, low pressure return bends, exchanger and condenser castings, pumps, etc., subjected to long periods of heating may not require irons of unusual strength, but do require that their original physical properties do not deteriorate appreciably.

Figure 13 summarizes results of quick tests upon a number of cast irons. Iron No. 6 is a malleable iron base specially processed while Numbers 7 and 8 would require special melting methods other than the cupola. It is evident from a comparison of cupola irons 2 and 3 and also from a comparison of high test types No. 4 and 5 that low silicon, low carbon alloyed cast irons are best fitted for high temperature loading.

Creep tests were made by Allen[7] on three of the irons described above. It is interesting to compare the low silicon, nickel alloyed, moderate strength, gray iron with its unalloyed companion as shown in Figure 14 and Table XV. It is apparent that a high test iron, sufficiently low in silicon, and fortified with alloys in the manner illustrated in Iron No. 5 above, would excell the unalloyed high test iron both in initial strength, creep strength, and resistance to deterioration. An outline of suitable compositions is suggested in Table XVI below:

TABLE XV

After 2015 hours under load at 700° F. the test bars were removed from the creep-test apparatus and subjected to the tension test at room temperature.

	Tensile Strength at Room Temperature, Lbs. Per Sq. In.			Brinell Hardness	
	Before Creep Testing		After Creep Testing	Original	Measured at Room Temperature After 2,015 Hours at at 700° F.
	Maximum	Minimum			
Gray iron	33,900	31,500	29,750	197	156
"Wompco" high-test iron	48,300	45,000	48,250	237	217
Nickel iron	48,100	47,400	47,500	230	216

[7]A.S.T.M.-A.S.M.E. Proceedings, 1931, R. J. Allen, Worthington Pump Co.

TABLE XVI

Limiting Temperature 450°F. A.S.T.M. Class 30 or less. i.e., under 30,000 p.s.i.

	TC	Si	Ni	Cr and/or Mo
Light Sections down to ⅛"	3.40 max.	2.50 max.	1.50*	.15* to .30*
Heavy Sections up to 2"	3.40 max.	1.50 max.	1.50*	.40* to .70*

*Optional for lower strength range. Necessary for stability at upper strength range.

Limiting Temperature 600° F. A.S.T.M. Class 30 to 60, i.e., 30,000 to 60,000 p.s.i.

	TC	Si	Ni	Cr and/or Mo
Light Sections down to ¼"	3.20 max.	1.60	1.25–2.0	.15–.35
Heavy Sections up to 2½"	3.20 max.	2.10	1.25–2.0	.30–.60

Limiting Temperature 750° F. A.S.T.M. Classes 40 to 60, i.e., 40,000 to 60,000 p.s.i.

	TC	Si	Ni	Cr and/or Mo
Light Sections down to ¼"	3.0 max.	2.0 max.	1.5–2.5	.15–.35
Heavy Sections up to 2½"	3.0 max.	1.20	1.5–2.5	.30–.60

Where creep may proceed to the extent of several percent, as in some unfired pressure vessels, such as heat exchangers, condensers, valves, pumps, return bends, fittings, etc., close specifications upon composition, strength and growth are obviously necessary or irons which possess one of these qualifications, such as strength, might readily fail in resistance to creep or growth. Good practice suggests further that castings for elevated temperatures be subjected to a stress-relief anneal, consisting of heating slowly to some temperature up to 1000°F., max., but above the highest casting operating temperature to eliminate stresses introduced during casting.

(To be concluded)

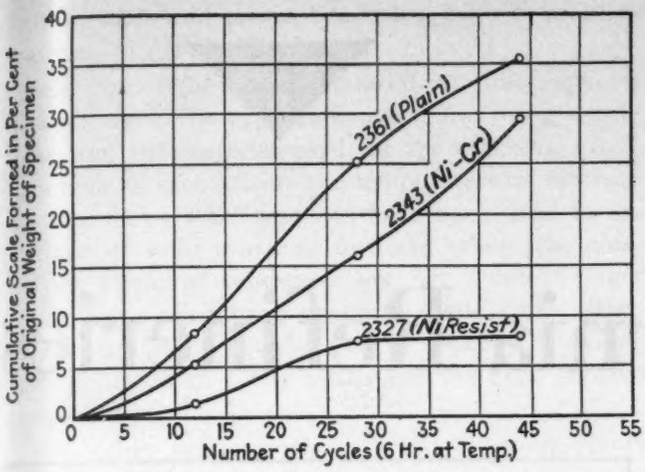

Cumulative Scale Formed in Per Cent of Original Weight of Specimen
2361 (Plain)
2343 (Ni-Cr)
2327 (Ni Resist)
Number of Cycles (6 Hr. at Temp.)

FIGURE 12

Inhibition of scale formation in cast iron (oxidizing atmospheres at 1500 F.) is important in applications requiring transfer of heat.

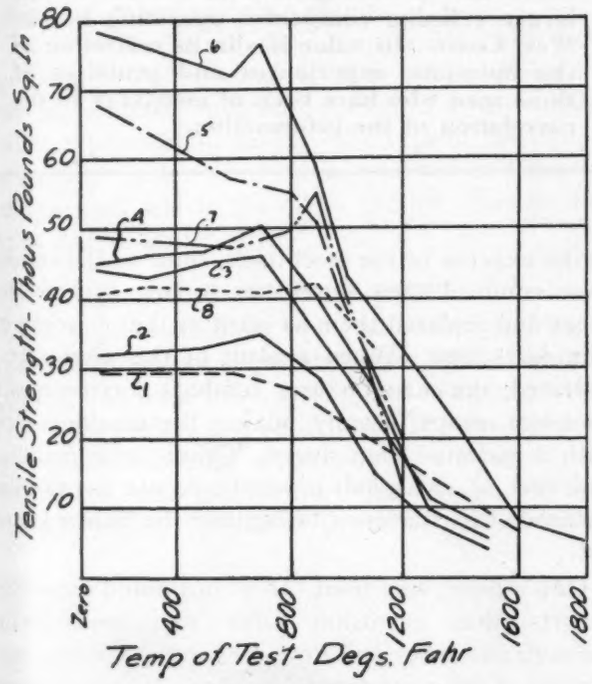


FIGURE 13

Short Time Tensile Strength Tests at Elevated Temperatures of Irons of the Following Compositions:

Number ..	1	2	3	4	5	6	7	8
Total carbon..	2.95	3.40	3.20	2.95	2.78	2.60	2.40	2.61
Manganese ..	0.85	0.75	0.85	0.75	0.80	0.25	0.70	0.82
Silicon ..	1.64	1.50	1.15	2.45	1.79	0.90	1.57	1.20
Nickel ..	13.02	—	1.50	—	1.59	1.25	1.34	2.39
Copper ..	6.29	—	—	—	—	—	—	—
Chromium ..	3.55	—	—	—	—	0.40	—	—
Temp. of falling off in strength .	600	700	700	700	800	800	900	900

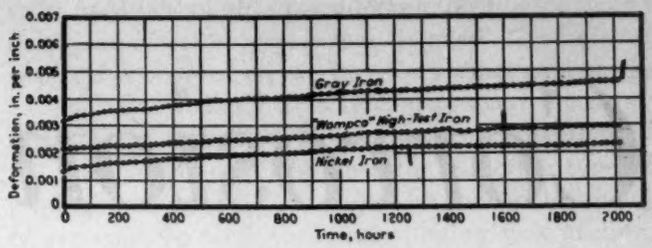


FIGURE 14

Time-deformation curves for three irons. "Gray Iron" corresponds to No. 2 of Figure 11. "Nickel Iron" corresponds to No. 3 of Figure 11. "Wompco" corresponds to No. 4 of Figure 11.

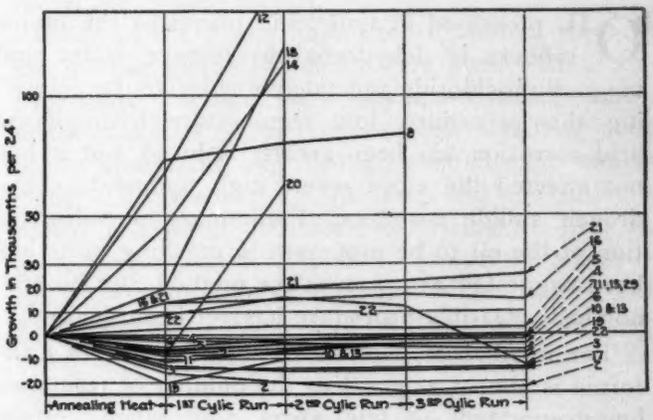


FIGURE 15

ALLOYED CAST IRON

No.	Fe	Cr	Ni	Si	C	Mn	Cu
1	72–70	28–30					
2	62	25	10	3			
3	52	23	23	0.5	0.8	0.5	
4	67	21	12		0.25		Welded
5	50–41	18–22	30–34		0.4	2–3	
6	16–14	18–20	65	0.6		1	
7	41	18	38	1.25–1.5	0.4–0.5	0.75–1.0	
8	44–39	17–19	37–39	1		1	
9	48	15	35	1–1.4	0.45–0.65	0.5–0.7	
10	55	14.6	30		0.26		
Ni-Resist		4.07	14.26	2.05	3.16		6.34
12		0.5	0.3	2.0	3.3	0.65	

Heat Resisting Castings—13, 14, 15, 16.
Stainless Steels—17, 18, 19.
Cast Irons—20, 21.
Structural Steel Welded—22.

Corrosion in California Refineries

J. C. ALBRIGHT

PART II

THE accompanying discussion constitutes Part 2 of the series of articles describing methods of combating corrosion of refinery equipment in California. In preparation of this series the author was assisted by engineers and technologists with several of the larger refining companies operating on the West Coast. Its value lies in its reflection of the opinions, experiences and practices of those men who have been of assistance in the correlation of the information.

OIL processed in California plants of the major refiners is dehydrated to remove water and magnesium chloride and calcium chloride. By following this procedure, low temperature hydrochloric acid corrosion has been greatly reduced, but it has not affected the more severe high temperature hydrogen sulfide corrosion. Preliminary de-sulfurization of the oil to be processed in cracking units has been suggested as a preventive method, but no economically feasible procedure has yet been devised.

The number of corrosion remedies used in California is almost as great as the number of refineries being operated. A few years ago, when certain chrome-nickel steels were advocated as a suitable metal from which cracking still tubes could be manufactured, several of the refiners equipped their cracking stills completely with this alloy, only to discover later that it was not altogether suitable for extreme high temperature service because of its tendency to become brittle, due to the precipitation of carbon at the grain boundaries, and to fail without warning. All of the companies have not found it to be entirely unsuccessful, however, and some are continuing to use it. A number of cracking units are still equipped with tubes of "18-8," but to operate them in the higher temperature brackets, it has been found necessary to attach thermocouples to each tube that is expected to encounter heat from the combustion chamber sufficiently high to endanger the operation of the plant. This "hot-spot" in the tube bank limits the operation of the plant to temperatures below that desired in some cases.

A number of refiners who have conducted tests with this metal ("18-8") in comparison with ordinary low carbon steel, have reported that it has a resistance to high temperature, high pressure, corrosion of over 100 times that of the low carbon samples used in the experiments.

Because of the high initial cost of installation, due to the expense of the steel itself, some of the refiners have confined their purchases to low carbon steel tubes and replaced them as often as they become too thin for safety. When a plant of this character is operated, the manufacturer combats corrosion with chemical means, usually mixing the cracking stock with a hydrated lime slurry. Others who manufacture fuel oil, or asphalt products, do not use the lime because of its tendency to degrade the finished product.

One refiner, who used "18-8" in limited quantities, reports that corrosion rates vary considerably through the tubes and now uses a low chrome alloy instead of the more expensive alloy. These tubes are manufactured of 4-6 chrome, or a 4-6 chrome plus ½ percent molybdenum. Low chrome steel tubes are from 2½ to three times as expensive as plain carbon steel tubes, but the life of the alloy, under severe conditions of high temperature corrosion is expected to be from 10 to 20 times that of the plain carbon steel.

As erosion within the cracking tubes has been found to increase the corrosion rates, some refiners have fitted the ends of the tubes with liners to combat both corrosion and erosion. Where turbulence is great it has been found expedient to supply the stills with stream line fittings. The combination of liners and such fittings has reduced tube and header failure considerably. One refiner who has equipped his cracking plants with these fittings, reports that wear

on tube ends and return bends has been reduced as much as 75 percent.

Selection of the proper material for tube supports depends upon the type of furnace, the firing conditions, and the material used for the cracking tubes, inasmuch as each affects the temperature of the tube support. Iron tube supports have been used to advantage in some cracking furnaces where the combustion chamber conditions are not severe. Other plants have used tube supports made from alloys containing small percentages of nickel chromium, and aluminum to safely withstand the high furnace temperature.

Still other refiners who operate cracking plants have found that cast tube supports of heat resisting steels containing a large percentage of nickel are necessary for satisfactory operation. In some refineries the tube supports have been successfully protected from overheating and oxidation by coating them with gunite, spraying it on the supports with a cement gun and compressed air.

Some refiners equip their transfer lines with metals carrying a high chrome content, while others have not encountered sufficient corrosion at this point to cause appreciable damage. The type of the unit, the conditions under which it is operated and the temperature at which the oil is carried through these lines differs materially.

CHROMIUM PLATING

Many methods have been tested in handling the corrosion problem in reaction chambers. Chromium plating has been tried, and in one instance, a chamber 10 by 40 feet was so plated. The preparation of the steel surface for electroplating consumed about 600 hours, and the plating itself about 150 hours. Approximately $30,000.00 worth of chromium salts were used, although a considerable portion of it was recovered after the vessel was finished. The finished vessel was covered on the interior surface to a thickness of 0.003 inches. This type of protective coating is not only expensive but subsequent operation of the vessel convinced the operator that this type of protection is not satisfactory. The principal difficulty encountered with chromium plating was peeling. The difference in the co-efficient of expansion between the plating and the metal base prevented a close permanent adherence of the two. Another difficulty arose from the cleaning out operation; the workmen entering the chamber set their tools against the sides of the chamber, resulting in nicks and particles of the chromium plate being removed. This exposed the surface of the steel to the corrosive action of the active agents responsible, and severe localized pitting resulted. The companies generally are not at all satisfied with this method of corrosion protection.

Some of the plants have tried a method whereby the interior of the chambers were lined with aluminum plate, but this, also, was found to be unsatisfactory because of the relatively low softening point of the aluminum, and its high coefficient of expansion. This resulted in buckling and the ultimate breaking down of the liner. Calorizing has been reported unsuitable for reaction chambers, because of the same difficulties encountered while cleaning out. Picks and other tools used by the workmen easily penetrate the thin coat which results in pitted corrosion.

Considerable experimental work has been done in an attempt to protect partially worn chambers by welding onto the steel surface plates or sheets of corrosion resistant materials, such as 5-15 percent chrome, "18-8" and other alloys. Some of the re-

Top of run tank consumed by hydrogen sulfide.

Section of pontoon roof showing corrosion of side next to distillate.

Section of water line showing growth of corrosion due to water conditions.

finers who are now doing development work in this field state that they have had only moderate success with the low chrome plates. The austenic, or chrome-nickel alloys, it is said, become brittle and crack in service, which permits the corrosive agents to creep through to the base metal beneath the plates. These plates were applied by lining the interior of the vessel and welding it to the surface through ¾-inch holes at four-inch centers.

Spraying metals with a gun, while looked upon as the equivalent of plating, has not given satisfactory permanent results. In the first place, it has been extremely difficult to prepare a surface the size of a reaction chamber securing the proper roughness so that corrosion resistant metals will adhere. When applied, coke cleaning tools penetrate the thin overlays (between 0.005 and 0.020 inches) and permit the action of the corrosive agents to penetrate the chamber metal in pits. The proponents of this protective process claim that the cost of patching and repairing is so low that the coating may be resprayed as often as found necessary to take care of blistering loss, and still involve a low overall maintenance cost.

A number of refiners are using a non-metallic lining as corrosion protection for vertical reaction chambers and flash drums, with varying degrees of success. A ganister type of lining consisting of a mixture of fire brick or quartz sand with a mineral binder of concrete has been relatively successful and is used extensively in vertical chambers. In the same type of chamber there has been used a sodium silicate type liner with porcelain, terra cotta, brick, clinker and various mineral oxides, for the body.

Before these liners are installed, anchor hooks are welded to the interior of the shell at fairly close centers with mesh wire stretched and fastened to the anchors at about an inch from the steel surface. The lining material is then trowled over and through the mesh down to the freshly sand-blasted steel surface. Some companies have used mineral wool, asbestos and other ingredients with the cement. The cement type of linings are cured for 48 hours in an atmosphere of exhaust steam, followed by the usual finishing cure. The silicate lining is heated gradually to 900°F. to produce uniform dehydration without checking or blistering.

One refiner lines his vessels with common red brick where the temperatures of processing are not too high to prevent. This company reports this method quite satisfactory for special purposes, but where the temperatures do not permit the use of common brick, gunite and asbestos cement have proved the most economical lining. All of the above types of chamber lining have been found to be relatively inexpensive and can be repaired at a small cost. The principal difficulty encountered in applying a non-metallic lining is that of obtaining a good bond between the lining and the metal, and to obtain a sufficiently hard and uniform surface which will resist mechanical abrasion.

NEUTRALIZERS

The use of chemical neutralizers in combating corrosion in California refineries has been, and is still being used to a large extent. Quoting one refinery technologist: "Although the mechanism of high temperature corrosion is not fully understood, and the effect of various corrosive compounds is still controversial, the refinery technologist has demonstrated that the use of certain alkaline chemicals will reduce corrosion. The classification of these alkaline chemicals as neutralizers may be a misnomer, since the role of acids in high temperature corrosion is not established. However, they are to be considered as neutralizers since they represent an effective means of combating refinery corrosion. These neutralizers may exert a number of different effects; they may combine with the corrosive sulfur compound and inhibit the corrosive action; they may react with the naphthenic acids to produce inactive soaps, or they may form a resistant protective coating on the metal surface.

Hydrated lime, or calcium hydroxide, when used as a neutralizer, is usually slurried with a light oil to form a mixture that can be pumped into the charging stock at the desired strength. The optimum quantity to be added must be determined for each particular case, but it is usually kept sufficiently low so as to produce a salable fuel oil from a standpoint of solid matter. It may average from 0.1 to 1.5 pounds per barrel; the latter requiring the removal of the spent reagent from the residuum. Lime cannot be used where tube velocities are so low that the suspended matter will settle out and reduce the heat transfer through the tubes. Consideration must be

given to plugging of centrifuge pumps or scaling of reciprocating pump pistons and cylinders. Most reports show that these difficulties are so serious that very dilute strengtl. must be used which results in corrosion reduction not being very effective.

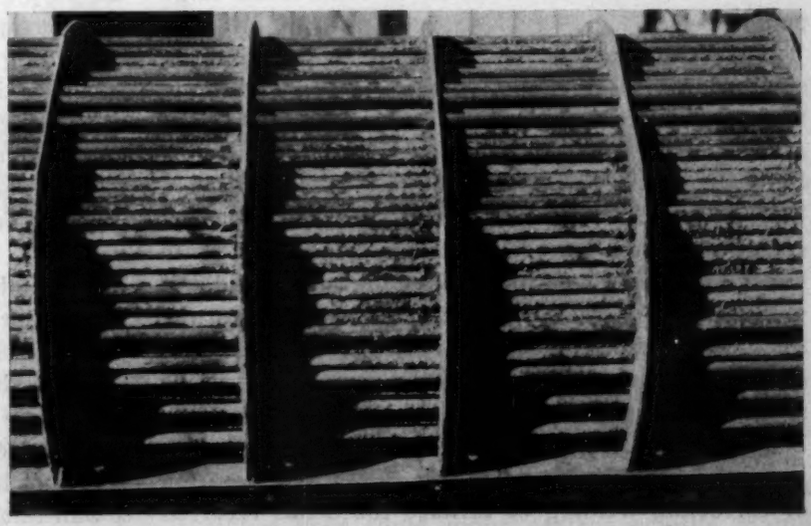
Caustic soda can be used in much smaller quantities than lime, and is usually injected into the charging stock in very strong solutions of from 15° to 25° Be. Although it is very effective in inhibiting high temperature corrosion, it has a number of detrimental features. It has a pronounced effect on the treating or purifying qualities of naphthenic base lubricating distillates. If the spent sodium salts are left in the fuel oil, it may cause excessive slagging of the fire brick in the oil fired furnaces or boilers. Also, if the residuum is to be used for the manufacture of asphalt, considerable trouble may result in the production of an undesirable emulsified product.

Another major disadvantage is the hazard of caustic embrittlement. It is a well established fact that, at high temperatures, hydrogen, ammonia and other reducing gases penetrate iron or copper and their alloys, and can cause intercrystalline corrosion and the development of cracks at the grain boundaries by the reduction of the oxides. Solutions of 20 percent and stronger caustic will rapidly attack iron, forming hydrogen. The caustic will also dissolve certain sulphur and silicon compounds and weaken the structure at the grain boundaries. This is particularly true in zones around rivet holes or welds or where the steel has been stressed sufficiently to have set up already focal points favorable for the initial caustic corrosion or embrittlement. Brasses may be corroded by caustic solutions because of the solution of the zinc, thereby resulting in dezincification. A large number of fractures have been reported relative to caustic embrittlement which is being used to inhibit another type of corrosion in the same equipment. In using the chemical as an inhibitor, precautions must be taken to use the solution in such a manner that it cannot be deposited, particularly at points of high metal stress, and also against degradation of fuel oil and asphalt qualities.

Ammonia has one distinct advantage as a high temperature neutralizer in that it is volatile and can be distributed throughout the towers, and can be carried over with the vapor distillate fractions and not impair the quality of the residual oils as do the solid reagents, lime and caustic soda. It has one main disadvantage, however, in that it is not particularly effective in inhibiting high temperature corrosion from hydrogen sulfide. In practically all cases where ammonia has been found effective, it has been in the range of so-called low temperature corrosion. As it is of questionable benefit for combating high temperature corrosion, it is not recommended for that service. Furthermore, in high temperature service, ammonia will cause caustic embrittlement and is very corrosive to copper bearing metals.

Bubble caps and trays in one refiner's equipment are fabricated from "18-8" when corrosion rates are high. This plant had encountered down-time corrosion which affected ordinary steel trays and caps where corrosion was not particularly severe. Each time the column was inspected before beginning a run, pitted conditions were found to exist in the steel where moisture could accumulate. Upon analyzing the water to determine whether or not it contained anything injurious to the metal, a weak hydrochloric acid condition was found to exist, which was brought about by the cooling of the column below the dew point with subsequent corrosion during idle periods. To overcome this condition, each time a unit is taken from the line with the expectation of remaining idle for a number of days, or weeks, the columns are opened and the trays with their caps are taken from the tower and stacked in the yard. By this method, corrosion has been retarded considerably.

Low temperature, low pressure corrosion has been defined as that encountered in topping or skimming plants. Corrosion from the effects of hydrogen sulfide is comparatively negligible in these units, but considerable reaction is encountered from hydrochloric acid when magnesium or calcium chloride is hydrolized or broken down by heat. The effect of this corrosion is most noticeable in accumulator drum, run-down receivers and water legs. Some of the refiners use a weak solution of caustic introduced in the vapor line to counteract this difficulty. Others use ammonia, either aqueous or anhydrous. One refiner in the northern part of the state, located where



Corroded section of tube bundle caused by hydrogen sulfide forming iron sulfide on steel tubes.

a large quantity of aqueous ammonia is manufactured, uses this chemical in preference to the anhydrous because of its nearness to the refinery and finds it well adapted to his requirements.

Others report that low temperature, low pressure corrosion in skimming plants is confined chiefly to condensers and exchangers. One overcomes this difficulty by metallurgical means, rather than chemical reagents. His exchangers are fitted with steel tubes where oil to oil is treated, or oil vapor to oil. Admiralty metal tubes are used in equipment for steam or water service in heating or condensing and cooling the oil or products of distillation.

Soil corrosion of plant pipe lines varies as to the location of the plants. Where the terrain is more rolling and presents a good drainage surface, the exterior deterioration of plant pipe lines does not progress as rapidly as where the yard is flat with no natural drainage. However, the condition of the soil and its corrosive influence on steel has been recognized for some time, and the majority of refiners place all lines in concrete lined trenches. This method not only prevents contact with corrosive agents in the soil, but places the lines where they are easily accessible for any purpose.

A program is in effect with one refiner who cannot well place lines in concrete trenches, to prevent further corrosion of the buried pipe. The lines are excavated by digging an open trench in the soil sufficiently wide that the lines are exposed at all points. Sand blasting is employed in removing all accumulation of scale, after which they are inspected closely for deep surface pits. These are filled by spot welding, after which the entire outer surface of the line is covered with a coat of asphalt to a thickness of approximately 3/8 inches. After this coat has set to its natural hardness, a coating of concrete is applied with a thickness of about one half-inch. The mixture of sand and cement is graded as to the fineness of the sand which is screened to remove all large pebbles.

When the concrete has hardened and dried sufficiently, a finishing coat of asphalt is applied with a thickness of about 3/8-inch as in the first coat. The covered line is then re-buried. A few lines that had been treated in this manner a few years ago have been excavated for various reasons and had not been corroded by soil contact. The concrete intermediate cover had hair lines and checks, but these did not extend through the inner coat of asphalt. When the lines were scraped to remove the asphalt, the surface of the steel appeared to be in the same condition as it was when it was sand-blasted, and the color was bright.

While not being responsible for the mitigation of corrosion, welding of furnace tubes has received considerable attention at one refinery. There has always been some controversy as to the advisability of welding furnace tubes, transfer lines and other equipment for high temperature service. This refiner has been welding such tubes for about 10 years, using only well trained men and high grade welding rod for the purpose, and reports that during this period, there has not been a tube failure at the weld. Welding is usually done for the purpose of retipping furnace tubes, when the ends showed excessive thinning from erosion and corrosion.

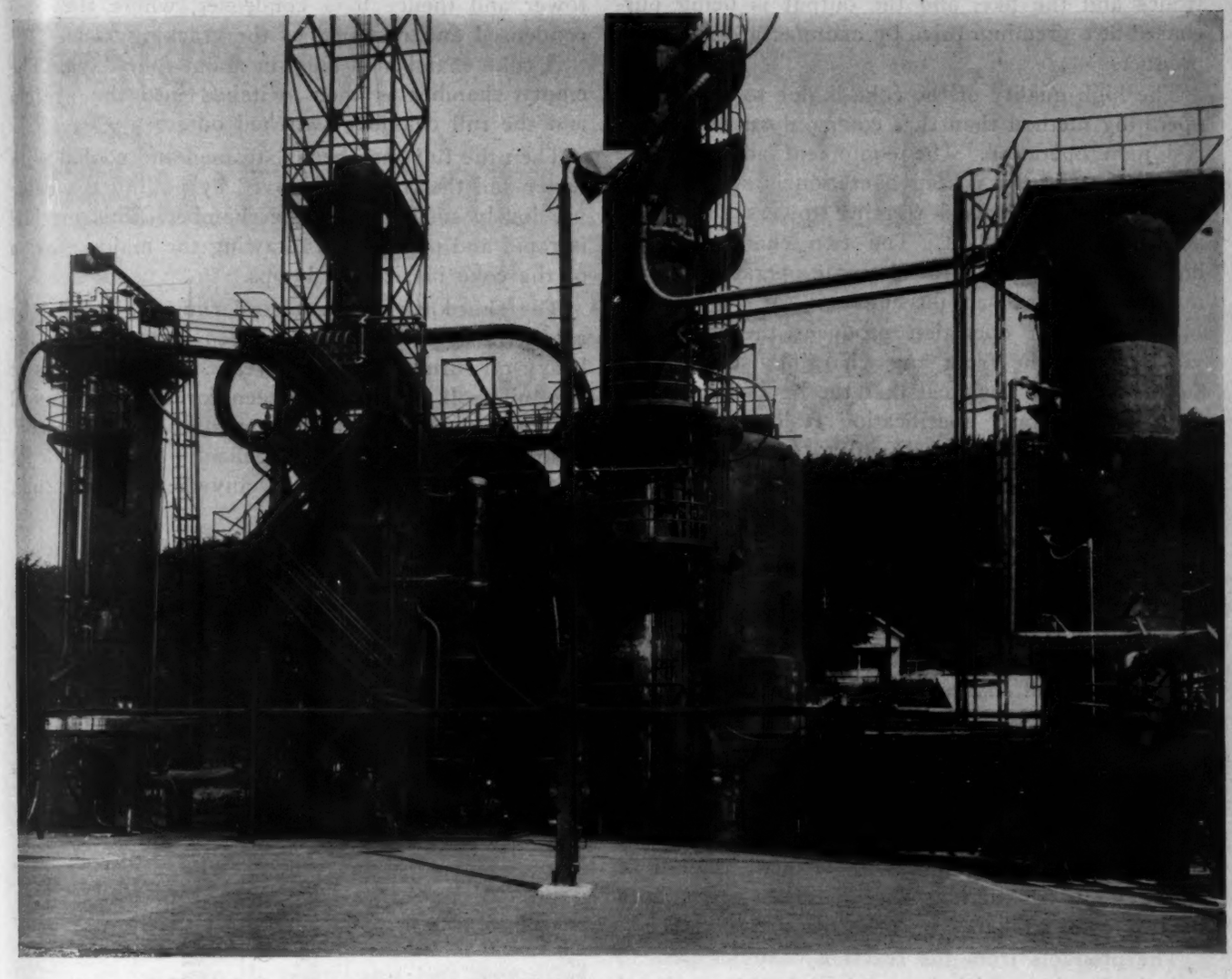
This same company has found that welding of heavy chambers is satisfactory. In one instance welding was used around a four-inch opening in a three-inch chamber wall. This chamber was one used as a reaction chamber placed in a horizontal position, and the cracks had occurred around the four-inch hole, some of which were about 1.5 inches in length. Steel pins were set in at the ends of the cracks to prevent further growth and the walls reinforced both inside and outside by welding heavy bosses or pads. This vessel has been giving service since the repair without showing other defects.

Some of the companies rigidly inspect all cracking equipment regularly, as well as other units where corrosion occurs to any extent. This is done by calipering the inside of all tubes, by drilling lines where corrosion is most active and measuring wall thicknesses, measuring the inside of pressure vessels and maintaining extensive records of findings at these points. In some vessels, measurements of the rate of corrosion are found by reference points, or bench marks of "18-8" steel attached to the inside of the shells. From the records kept of the various pieces of equipment the rate of corrosion can easily be determined, and when this rate is accelerated from any cause, inspection is made more often, and finally, when the wall thickness has reached a point where it is unsafe to operate the plant, the pieces showing loss of metal surface are replaced with others.

When it becomes necessary to remove tubes from a cracking furnace for any reason, one refiner makes it a practice to carefully inspect them. If in good condition otherwise, they are annealed in special furnaces to remove the brittle condition. This practice is observed particularly when the tubes were manufactured from high chrome, such as "18-8" chrome nickel.

The subject of corrosion as it effects refinery equipment is a large one, but from what has been gathered, it may be said that the California refiner is protecting his cracking equipment from corrosion largely by metallurgical methods; either he is equipping the cracking plants with corrosion resistant steels, or he is installing plain low carbon steels with a wall thickness sufficiently heavy to insure long life.

(To be concluded)



View of Kendall Refining Company's Dubbs Cracking unit on which a 98 day run was recently completed. The two coking towers described are visible in the background, one behind the flash chamber and the other behind the fractionating tower.

Kendall Makes
Coking Run of 98 Days

F. J. HEALY[1], C. H. ALBERDING[2] and B. J. FLOCK[2]

A DUBBS cracking unit of Kendall Refining Company, Bradford, Pennsylvania, recently was shut down after a non-stop run of 98 days, which breaks all previous records for continuous operation.

The products made during the record run were anti-knock gasoline, and coke—a high quality coke, different from that usually produced in non-residuum cracking operations. This coke is very hard. It averages only about eight percent volatile matter. It is suitable for the manufacture of carbon elec-

[1]Kendall Refining Co.
[2]Universal Oil Products Co.

trodes and the like, and the output is being purchased at a premium price by manufacturers of such products.

The high quality of the coke is due to a different operating method than that commonly used in non-residuum operation. The equipment added to the unit to handle the coking operation is simple, consisting of two disused treating towers that were available in the plant. The two chambers were hooked up to the unit for alternate operation, which made the record run possible.

This type of operation produces the maximum yield of gasoline from any charging stock. The equipment is so designed that the operation can be changed from any specification residuum to coke and back again, without difficulty, to meet changing demands of the market.

The unit on which this run was made is a Dubbs two-coil selective cracking unit to which the above mentioned continuous coking equipment has been added. This unit has two furnaces in which the light and heavy fractions of the charging stock and recycle stock are processed separately.

The heavy oil charge is fed into the fractionating column. A hot oil pump takes a heavy oil fraction from the base of the column and discharges it into a heating coil.

A light oil fraction is removed by another pump from the side of the column and pumped to the light oil furnace, together with a small amount of water white distillate. The materials from both heating coils discharge into the reaction chamber.

The products from the reaction chamber pass to a flash chamber which is maintained under reduced pressure. The vapors from the flash chamber pass through a heat exchanger on the way to the fractionating column, while the residue is discharged into the coking chamber. Light recycle stock and the water white distillate are heated in this exchanger before entering the light oil furnace.

Gasoline vapors and gas are removed from the top of the fractionating column. The vapors from the top of the column pass to a parallel coil condenser and to a distillate receiver where the gas is separated. Pressure on the separating and fractionating system is maintained by the release of gas from the distillate receiver.

The distillate from the receiver is then pumped to a stabilizer and the gas goes to an absorption system.

The two towers in which the coking is done formerly were used to treat gasoline but after the development of Universal inhibitor this treating was abandoned and the towers lay idle until revamped for the new use.

The cracked residuum is pumped from the flash chamber to the coke chamber.

The vapors from the coke chamber pass to a tower and thence to a condenser, where they are condensed and returned to the cracking zone.

A coke chamber is filled in about four days. The empty chamber is then switched into the system and the full chamber switched out.

Then the full chamber is steamed and cooled with water and the coke is removed by pulling the cable previously suspended in the chamber. This method is rapid and permits withdrawing the major portion of the coke in sizeable lumps.

The shutdown of the record run was caused by a leak in a tube which had been in service in the heavy oil furnace for three years. The leak was at the tube roll. Had it not been for this mechanical difficulty the run could have continued, as the condition of the unit was excellent. No significant amount of coke was found anywhere in the unit during the shutdown.

A summary of the run mentioned above follows:

	Bbls.	Percent of Raw Oil	Bbls. Per Day
Light charge	23,956	....	244
Heavy charge	109,690	....	1,115
Total charge	133,646	....	1,359
Gasoline produced	99,932	74.8	1,016
Residuum	346	0.3	4
Coke	11,044	8.2	112
Gas and loss	22,324	16.7	227

Gas production—114,885,900 cu. ft.
Cu. ft. per bbl. charge—859.
Coke per bbl. charge—30 lbs.

Analyses of charge and products:

	Heavy Feed	Light Feed	Finished Stab. Gaso.
Gravity	38.6	46.2	61.0
I. B. P.	370	338	83
10%	519	394	110
50%	590	423	247
90%	690	466	379
E. P.	734	510	411
% Rec	97	98	97
% at 400° F.	0.5	16	Color 15
% at 572° F	37.0	....	Gum 3 mgs.
Carbon res.	0.058	....	Vap. Pres.—10.6
Pour	40	....	.....
BS&W	Trace	....	.....

The above results demonstrate the success of this operation. It is possible to produce fuel oil at any time there is a demand for it or to produce a high quality salable coke whenever it is more profitable to do so.

The run now in progress gives indications that the results of the record run may be bettered. In this run, after 40 days of operation, the average gasoline yield was 79 percent, or four percent higher than in the record run. In addition, a 200-barrel per day increase in throughput has been effected, accompanied by a decrease in fuel consumption. These improved results are due to small changes made in the equipment after the 98-day run.

During 23 hours of that run, the unit was producing residuum. The remainder of the time it was on coking operation. During the run 1949 tons of coke were produced. This coke was loaded directly into cars from the coke chambers by means of conveyors.

Design of Fractionating Columns

(ARTICLE 2)

Number of Plates for Gas and Gasoline Fractionators

PART 1

GEO. GRANGER BROWN, MOTT SOUDERS, Jr., H. V. NYLAND, (a) and Wm. W. HESLER (b)

University of Michigan, Ann Arbor, Mich.

THIS is the second of a series of papers dealing with fractionating column design. It is presented in the columns of the Refiner because of the interest evidenced in the publication of Part 1 of the series which appeared in January, 1934, page 32, Volume 13, No. 1. The accompanying article adds to the value of the series through its completeness secured through detailed discussion. Because of its length the present work is presented in two parts, and will be concluded in the Refiner for May.

This paper was one of a symposium on distillation presented at Cambridge, Mass., late in December of last year. It is presented here through courtesy of the authors, the American Chemical Society and Industrial & Engineering Chemistry.

THE absorption factor concept proposed by Kremser[3] and applied by Souders and Brown[5] to gas absorbers and oil strippers has been previously suggested[1] as an apparent satisfactory basis for calculating the number of equilibrium plates required in fractionating columns. The original procedure included some unsatisfactory assumptions which have been eliminated in the improved and simplified method herein described.

The absorption factor method uses an absorption or stripping factor in an equation which involves the number of equilibrium plates required over a section of a column to effect the change in terminal concentrations of an individual component. The method may be applied to one component at a time and is not limited to relatively complete separations between adjacent components.

If the quantities of ascending vapor and descending liquid are assumed to be constant, a material balance for any one component and around any plate above the feed, gives the equation*:

$$y_{n+1} = y_n + \frac{L}{V} x_n - \frac{L}{V} x_{n-1} \qquad (1)$$

Under equilibrium conditions $y = Kx$ (2)

Substituting the equilibrium equation 2 and the absorption factor, $A_n = \frac{L}{K_n V}$, equation 1 becomes

$$y_{n+1} = (1 + A_n)\, y_n - A_{n-1}\, y_{n-1} \qquad (3)$$

Application of this equation to a number of successive plates leads to the general equation

$$y_{n+1} = (A_1 \ldots A_n + A_2 \ldots A_n + \ldots + A_n + 1) y_1 - A_1 (A_2 \ldots A_n + A_3 \ldots A_n + \ldots + A_n + 1) K_1 x_0 \qquad (4)$$

If the absorption factor, A, is a constant the equation may be written

$$\frac{y_{n+1} - y_1}{y_{n+1} - K_1 x_0} = \frac{A^{n+1} - A}{A^{n+1} - 1} \qquad (5)$$

where y_{n+1} = concentration of any component in the vapor entering a section of the rectifying column;

y_1 = concentration of the same component in vapor rising from the top plate of the section;

x_0 = concentration of same component in liquid entering the top plate of the section;

K_1 = equilibrium constant for same component at the temperature of the top plate of the section;

n = number of theoretical plates in the section;

$A = \frac{L}{K_A V}$, in which K_A is the equivalent constant value of the equilibrium constant for the same component.

A similar derivation for a section of the stripping column leads to the equation

(a) Present address: Sinclair Oil Refining Company, East Chicago, Indiana.

(b) Present address: Parsons Eng. Co., Mt. Vernon, Ohio.

* Nomenclature for all equations given at end of article.

$$\frac{x_e - x_m}{x_e - \frac{y_{m+1}}{K_m}} = \frac{S^{m+1} - S}{S^{m+1} - 1} \qquad (6)$$

where x_e = concentration of any component in the liquid entering a section of the stripping column;
x_m = concentration of same component in liquid overflowing from the bottom plate of the section;
y_{m+1} = concentration of same component in vapor entering the bottom plate of the section;
K_m = equilibrium constant for same component at the temperature of the bottom plate of the section;
m = number of theoretical plates in the section;
$S = \frac{K_s \overline{V}}{\overline{L}}$, in which K_s is the equivalent constant value of the equilibrium constant for the same component.

In setting up the conditions for a design problem for a given complex feed, only total pressure, reflux ratio, quantity of distillate, mole fraction of one component in the distillate, and mole fraction of another component in the bottoms, may be fixed. All other compositions and quantities are dependent. Usually the more volatile components may be assumed to be absent from the bottoms and the less volatile components absent from the distillate, leaving only two or three components to be distributed between distillate and bottoms. The compositions of the distillate and bottoms computed on this assumption are adequate for making material balances.

Temperature of Feed Plate.—Since the vapor rising from the feed plate is the feed to the rectifying section, and the liquid overflow from the feed plate is the feed to the stripping section, it is necessary to calculate the compositions at the feed plate depending upon the temperature of the feed plate. If it is assumed that the temperature gradient between top and bottom terminal plates is linear, the temperature of the feed plate may be calculated from the equation

$$t_f = t_t + \frac{n}{n+m}(t_b - t_t) \qquad (7)$$

where t_t = temperature °F. of top terminal plate
t_b = temperature °F. of bottom terminal plate.

Since the number of plates above and below the feed is not yet known, this equation involves a trial and error procedure, which rapidly yields a satisfactory solution.

Temperature and Composition at Top Plate.—By neglecting, as conservative practice, any fractionation in the overhead condenser, the vapor rising from the top plate may be assumed to have the same composition as the top (overhead distillate) or product. The equilibrium temperature at the top plate may then be calculated from the composition of this vapor[2].

In many cases the temperature gradient between the plates at the top of the column is not linear. In such cases equations 1 and 2 should be used to compute the compositions and equilibrium temperatures for a few plates below the top until the temperature gradient between successive plates is substantially uniform, to determine a plate that may be used as the top terminal plate for application of the absorption factor.

Temperature and Composition at Bottom Plate.—The composition of the liquid leaving the bottom plate may be calculated by assuming that the bottoms product is in equilibrium with the vapor entering the bottom plate and by making a material balance around the reboiler or kettle. The temperature difference between successive plates near the bottom is usually far from uniform, and it is advisable to use equations 1 and 2 to compute the temperatures for a few plates until the temperature gradient approaches a linear relationship, to determine the bottom terminal plate for the stripping factor.

Composition at Feed Plate.—The computed composition of the liquid leaving the feed plate must have as its bubble point the temperature of the feed plate estimated in the manner described. In order to fix this composition at the feed plate it is necessary to know the temperature and pressure and the concentrations of all but two of the components.

For components which do not appear in the bottoms it may be assumed that the mole fraction in the liquid leaving the feed plate is the same as that of the plate above[4] so that equation 8 may be applied. Similarly for components which do not appear in the distillate equation 9 may be used. Under these conditions a material balance for the more volatile components becomes,

$$K_{a_f} x_{a_f} = \frac{L}{V} x_{a_f} + \frac{D}{V} x_{a_D}$$

$$x_{a_f} = \frac{\frac{D}{V} x_{a_D}}{K_{a_f} - \frac{L}{V}} \qquad (8)$$

and for less volatile components

$$K_{d_f} x_{d_f} = \frac{\overline{L}}{\overline{V}} x_{d_f} - \frac{B}{\overline{V}} x_{d_B}$$

$$x_{d_f} = \frac{\frac{B}{\overline{V}} x_{d_B}}{\frac{\overline{L}}{\overline{V}} - K_{d_f}} \qquad (9)$$

When there are three components which appear in significant quantities in both overhead and bottoms, Equation 8 may be applied to the most volatile of these three components if the mole fraction of this component in the bottoms is small and the ratio of the number of plates above the feed to the number below the feed (n/m) is greater than two. The smaller the mole fraction in the bottoms and the larger the ratio of plates, the more applicable is Equation 8. Equation 9 may be applied to the least volatile component appearing in both overhead and bottoms if the mole fraction of this component in the distillate is small and the ratio n/m is less than one third. The smaller the mole fraction in the distillate and the smaller the ratio of plates, the more applicable is Equation 9.

The mole fractions of all but two components in the liquid leaving the feed plate may usually be determined as described. The mole fractions of these two inter-

mediate components may be determined from the estimated temperature of the feed plate and the two relationships: (1) sum of mole fractions of all components in the liquid leaving the feed plate is unity; and (2) sum of the products of Kx for all components is unity. The equilibrium constants, K, are determined from the temperature and pressure of the feed plate, and the two simultaneous equations may be solved for the mole fractions of the two components whose concentrations in the liquid leaving the feed plate are as yet undetermined.

Application of Absorption and Stripping Factors.—It is assumed that the rectifying part of the column acts as an absorber of the least volatile distributed component and that the stripping part of the column operates as a stripper of the most volatile distributed component.

The value of the average or equivalent equilibrium constant K_A, of the absorption factor, A, for the least volatile distributed component may be taken as the average value between the upper terminal plate and the plate immediately above the feed plate.

$$K_A = \frac{K_t + K_{t-1}}{2} \qquad (10)$$

The temperature of the plate above the feed plate

$$t_{t-1} = t_t - \frac{1}{n+m}(t_b - t_t)$$

The value of the equivalent equilibrium constant, K_S, for the stripping factor, S, for the most volatile distributed component may be taken as the average value between the plate immediately below the feed plate and the lower terminal plate.

$$K_S = \frac{K_{t+1} + K_b}{2} \qquad (11)$$

The temperature of the plate below the feed plate

$$t_{t+1} = t_t + \frac{1}{n+m}(t_b - t_t)$$

Checking Assumed Temperature of the Feed Plate.—When the number of equilibrium plates between the terminal plates above the feed plate, n, and below the feed plate, m, have been determined by means of the absorption and stripping factor methods in the manner described, the assumed temperature of the feed plate is checked by using these values of n and m in Equation 7.

DISCUSSION

The use of the absorption factor for the design or the calculation of fractionating columns according to the method outlined involves assumptions which can be justified only if they yield reliable results. The estimated composition on the feed plate is not precise, particularly when more than two components are common to, and present in appreciable concentration in both overhead and bottoms, but is much nearer the actual conditions than the simpler but misleading assumption that the composition of the feed itself might be used for the composition of the feed plate.[1] Although use of the feed composition gave satisfactory results in special cases, it is an unsound assumption and should not be used.

If the composition of the components to which the absorption factor is to be applied, goes through a pronounced maximum between the terminal plates, the assumption of an average effective value for the equilibrium constant "K" as an arithmetric average between the terminal plates may lead to large errors, it appears that this difficulty may be eliminated by separating that part of the column into two sections with a terminal plate located at the maximum concentration of the component, or by applying the absorption factor method to a component which does not go through a maximum concentration between the terminal plates.

When reliable data are available from an operating column, it is not necessary to estimate the composition on the feed plate, and the column may be treated in a number of short sections so as to avoid the necessity of making these two assumptions. When applied in this manner the absorption factor method as outlined should give reliable results in all cases.

THEORETICAL COMPARISON OF METHODS OF CALCULATION

Because of the difficulty of obtaining actual experimental data on equilibrium plates, particular problems were set up and computed by stepwise calculations as a basis for comparison in determining the reliability of the absorption factor method. All reliable methods of calculation must give substantially identical results when applied to the same problem.

Stepwise Calculation.—Three-component mixtures of propane, butane and pentane were used for simplicity and because of available equilibrium data.[6] The pressure and composition of the feed were fixed, the quantity of distillate, reflux ratio, and two mole fractions in products were chosen, and attempts were made to calculate the number of plates, the composition on each plate, and location of feed plate by stepwise calculation similar to the method suggested by Lewis and Matheson.[4] Many practical difficulties were encountered and had to be solved by trial and error before satisfactory results could be obtained in even a limited number of cases.

With the method of Lewis and Matheson, where calculations must start with one of the terminal products, the complete composition of the products must be assumed at the start. This makes it necessary to revise the assumed compositions by trial and error on the basis of the stepwise calculations until compositions are obtained which permit a straightforward and consistent plate-to-plate calculation between the terminal compositions. Although this method of design is feasible for a three-component mixture where the approximate terminal compositions may be obtained by a material balance, for mixtures with more than three com-

ponents the method becomes so very laborious as to be impractical.

With the absorption factor method of design, most of the labor of trial and error calculation is avoided since the mole fractions in the terminal products of only the two or three distributed components are required to be known. Mole fractions of other components in the products may be calculated (not assumed) after the number of plates have been determined by applying the absorption factor method to the distributed components.

The following three component mixtures calculated by the method of Lewis and Matheson provide an independent check on the reliability of the absorption factor method.

Figures 1, 2, 3, give three attempts out of many to set up complete calculations when fixing the mole fraction of the least volatile component in the distillate at 0.01 and the mole fraction of the most volatile component in the bottoms at 0.01.

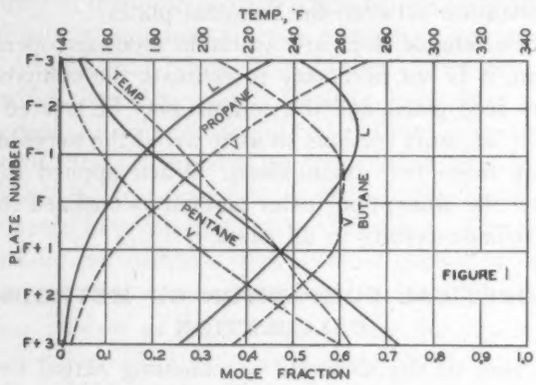


FIGURE 1

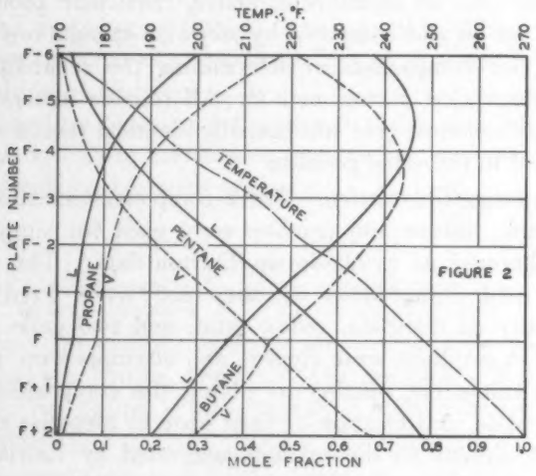


FIGURE 2

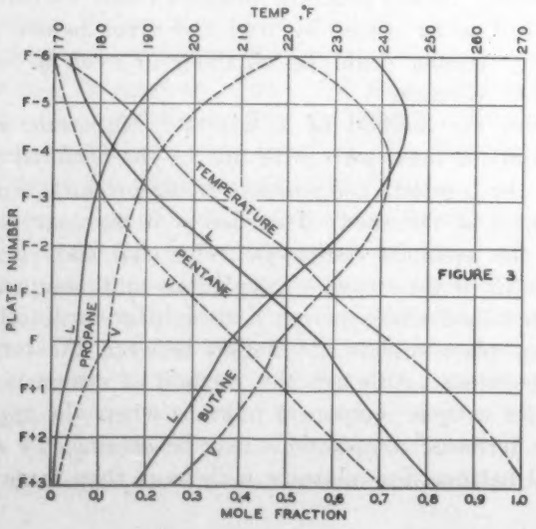


FIGURE 3

Figures 4, 5, 6 give the results obtained when trying to design for 95.99 percent of propane, four percent of butane and 0.01 percent of pentane in the distillate (which is 30 percent of the feed) with a reflux ratio of 9. In this case it was found more convenient to start the calculations at the bottom. In each case a fairly satisfactory solution was obtained almost regardless of the feed plate location insofar as the composition of propane and butane in the distillate are concerned, but the composition of pentane varies widely.

Table I gives a summary of these results and the results on a five-component mixture computed by Underwood.[7] The results computed by means of the absorption factor method using the distillate and bottoms as the terminal conditions are also included for purposes of comparison.

The Absorption Factor Method.—The application of the absorption factor method to the conditions used in calculating fractionating column 6 will serve as an example of the method.

Assuming the temperature of the feed plate to be 166°F. and applying Equation 9 to n-pentane.

$$x_{c_f} = \frac{0.233 \times 0.5}{1.233 - 0.324} = 0.1281$$

$$x_a + x_b = 1 - x_c = 0.8719$$

$$K_a x_a + K_b x_b = 1 - K_c x_c$$

$$1.59 x_{a_f} + 0.738\, x_{b_f} = 1 - 0.324 \times 0.1281$$

$$x_{b_f} = 0.5022$$

$$x_{a_f} = 0.3697$$

$$y_{b_f} = 0.3706$$

Applying the absorption factor to n-butane above the feed plate,

$t_t = 118°F.;\ K_t = 0.435$

$t_{f-1} = 153°F.;\ K_{f-1} = 0.64$

Average $K_A = 0.537$

$$A = \frac{L}{K_A V} = \frac{0.9}{0.537} = 1.67$$

$$\frac{y_f - y_D}{y_f - K_1 x_D} = \frac{0.3706 - 0.04}{0.3706 - 0.435 \times 0.04} = 0.935$$

From equation 5 (plotted in Figure 7) 3.8 theoretical plates are required above the feed plate.

Applying the stripping factor to propane below the feed plate,

$t_{f+1} = 179°F.;\ K_{f+1} = 1.69$

$t_b = 242°F.;\ K_b = 2.29$

Average $K_S = 1.99$

$$S = \frac{K_S \overline{V}}{\overline{L}} = \frac{1.99}{1.233} = 1.614$$

$$\frac{x_f - x_B}{x_f - \frac{x_B}{K_B}} = \frac{0.3697 - 0.01719}{0.3697 - \frac{0.01719}{2.29}} = 0.973$$

From Equation 6 (plotted in Figure 7) 5.7 theoretical plates are required below the feed plate.

Checking the assumed temperature of the feed plate (166°F.)

$$t_f = 118 + \frac{3.8}{9.5}(242 - 118) = 167°\text{F.}$$

The application of the absorption factor in the same manner to pentane in fractionators 4, 5 and 6 checks the number of plates in the rectifying section as calculated by the stepwise method even better than the application to butane (the less volatile cut-component). In column 6 this calculation indicates 3.4 + plates compared with 3.5 plates by the stepwise calculation. This indicates that the number of plates required in the rectifying column may be determined by the absorption factor as applied to any of the less volatile components whose composition in the distillate is significant.

If the number of plates above and below the feed plate have been determined by applying the absorption and stripping factors respectively to the least volatile and most volatile distributed components, Equations 5 or 6 may also be used to calculate the small concentrations in the distillate, or bottoms, of components which initially were assumed to be absent from these products.

DISCUSSION

A study of the results reported in Table I clearly indicates the sources of errors in the use of the absorption factor method as compared with the stepwise calculation. In fractionating column 1 the estimated feed plate composition for propane is in error by almost 50 percent and the error in the number of plates required in the stripping section to strip the propane from the estimated feed plate composition, is 20 percent. This error is the greatest indicated error in the absorption factor method as compared with the rigorous plate to plate computation, and is due entirely to error in the estimated feed plate composition.

In all other cases the feed plate composition as estimated by the absorption factor method agrees fairly well, within about 10 percent, with the composition of the feed plate as computed from the stepwise calculations. In fractionating columns 2 and 3, all three components are present in appreciable quantities in both the overhead and the bottoms, and the estimated composition of the feed plate is not as satisfactory as in columns 5 and 6 where a sharp separation is being made between two adjacent components.

Fractionating column 4 (Figure 4) is of particular interest as it is the only column included in Table I in which the significant cut component goes through a distinct maximum between the terminal plates. By referring to Figure 4, it is seen that the mole fraction of butane on the feed plate is 0.673 and that it increases to a maximum of 0.787 two plates above and then decreases to 0.069 on the top plate. In applying the absorption factor method to the absorption of butane in the rectifying section of this column, it was assumed that the average effective value for the equilibrium constant of butane in the rectifying column could be

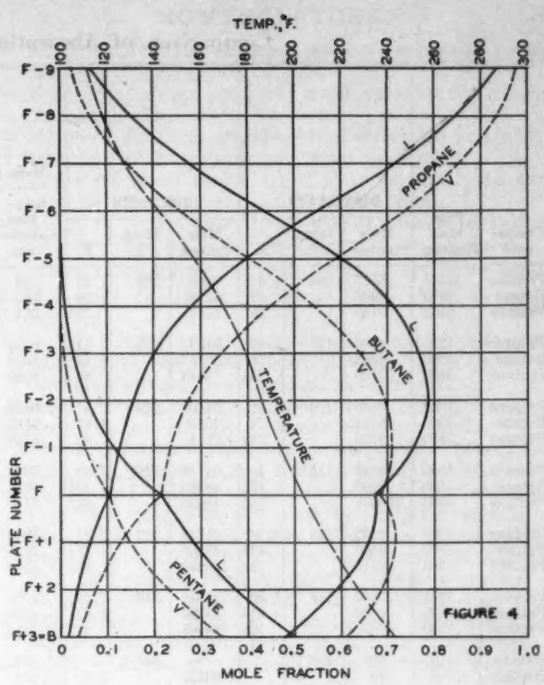


FIGURE 4

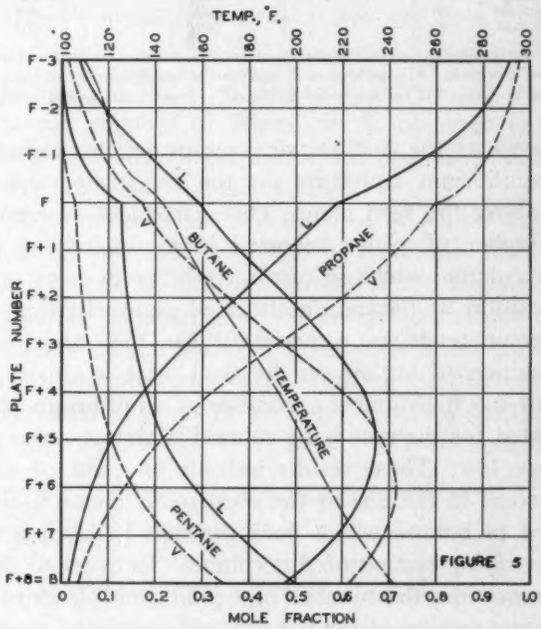


FIGURE 5

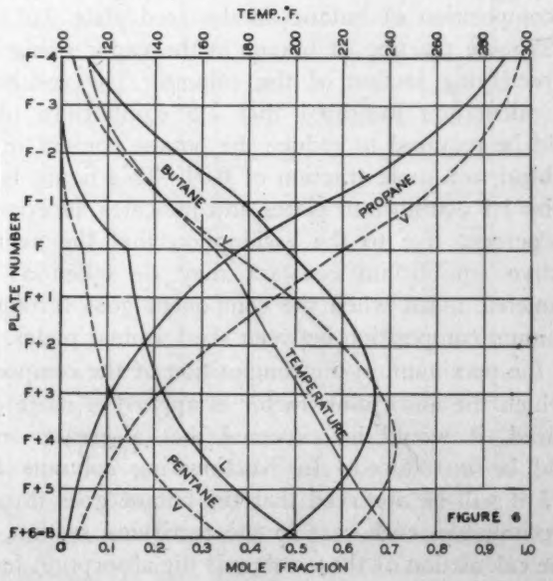


FIGURE 6

TABLE I
Comparison of Absorption Factor with Stepwise Calculation

Column No.	Component	Feed Mole Fraction	DISTILLATE Mole Fraction	DISTILLATE Temp. °F.	DISTILLATE "K"	BOTTOMS Mole Faction	BOTTOMS Temp. °F.	BOTTOMS "K"	FEED PLATE Mole Fraction Stepwise Calculation	FEED PLATE Mole Fraction Absorption Factor	FEED PLATE Temp. °F.	FEED PLATE "K"	D/F	L/V	NUMBER OF EQUILIBRIUM PLATES: Above Feed Plate n Stepwise Calculation	Above Feed Plate n Absorption Factor	BELOW FEED Stepwise Calculation	BELOW FEED Absorption Factor	Total No. of Plates n+m+1 Stepwise Calculation	Total No. of Plates n+m+1 Absorption Factor
I	Propane	.3333	.6567	153	1.46	.0100	258	2.41	.109	.0586	212	2.02	0.5	0.9	3	2.6	2.87	2.3	6.87	5.9
	Butane	.3333	.3333		.65	.3333		1.38	.560	.709		1.07								
	Pentane	.3333	.0100		.28	.6567		.788	.331	.2324		.53								
II	Propane	.1500	.47667	170	1.62	.0100	269	2.51	.0373	.0334	248	2.33	0.3	0.9	6	6	1.78	1.6	8.78	8.6
	Butane	.3000	.51333		.76	.20857		1.45	.3628	.3676		1.30								
	Pentane	.5500	.0100		.334	.78143		.86	.5999	.5990		.74								
III	Propane	.1500	.47667	170	1.62	.0100	269	2.51	.0520	.0500	243	2.28	0.3	0.85	6	6	2.5	2.4	9.5	9.4
	Butane	.3000	.51333		.76	.2086		1.45	.3740	.3670		1.285								
	Pentane	.5500	.0100		.334	.7814		.86	.5740	.5830		.698								
IV	Propane	.3000	.9599	118	1.10	.01719	242	2.29	.1089	.0936	204	1.94	0.3	0.9	8.6	8.0	3	2.7	12.6	11.7
	Butane	.3500	.0400		.435	.48286		1.274	.6730	.7058		1.02								
	Pentane	.3500	.000008		.166	.49995		.692	.2180	.201		.49								
V	Propane	.3000	.9599	118	1.10	.01719	242	2.29	.5840	.563	144	1.37	0.3	0.9	2.1	2.2	8	7.4	11.1	10.6
	Butane	.3500	.0400		.435	.48286		1.274	.2910	.320		.588								
	Pentane	.3500	.00102		.166	.49995		.692	.1250	.117		.238								
VI	Propane	.3000	.9599	118	1.10	.01719	242	2.29	.3736	.3697	166	1.59	0.3	0.9	3.5	3.8	6	5.7	10.5	10.5
	Butane	.3500	.0400		.435	.48286		1.274	.4820	.5022		.738								
	Pentane	.3500	.00023		.166	.49995		.692	.1444	.1281		.324								
VII	Hexane	.310	.536	187.9			285.3		.068	.0624	224.4	2.9	0.5777	.75	6	5.6	10	10.3	17	16.9
	Heptane	.266	.46			.00134		3.0	.422	.4602		1.29								
	Octane	.187	.00406		.29	.437			.368	.3480		0.566								
	Nonane	.125				.296			.082	.0726		.275								
	Decane	.112				.266			.060	.0564		.135								

Note:—Feed to columns I-VI considered as all liquid and at temperature of feed plate. Pressure 200 lbs. per sq. in. absolute. Feed plate compositions are for liquid on plate. Feed to column VII half vapor and half liquid. Pressure atmospheric. Equilibrium determined by Raoult's Law, K=p/P.

estimated as the arithmetic average of the values of the equilibrium constants on the top plate, and the plate above the feed plate. This introduces an error in the number of plates required in the rectifying part of the column, which in turn introduces an error in the composition of butane on the feed plate. In this case one error tends to compensate for the other. The composition of butane on the feed plate is almost five percent too high and the number of equilibrium plates estimated for the rectifying column is almost seven percent too low. These results indicate an error of about 12 percent in the use of the absorption factor itself as applied to butane which goes through a maximum in the rectifying section of this column. In order to check this indication, the number of equilibrium plates in the rectifying section of the column was computed using as the composition of butane on the feed plate 0.673, or 0.6865 mole fraction of butane in the vapor rising into the rectifying section of the column. The results of this calculation indicated that 7.5 equilibrium plates would be required to reduce the butane content in the overhead to a mole fraction of 0.04. This figure is too low by 1.1 equilibrium plates and indicates an error of 12.8 percent due to the assumption that the average effective equilibrium constant may be taken as the arithmetic mean when the component goes through a maximum composition between the terminal plates.

If the maximum in the composition of the component to which the absorption factor is applied is more pronounced, it would be expected that a greater error would be introduced. In fractionating columns 1, 2 and 3 it will be observed that the butane goes through a maximum in each case in the rectifying section, but in the calculation of these columns the absorption factor method is applied to pentane in the rectifying section and not to the butane, with satisfactory results in all cases. The error in the case of column 1 was due to an error in the estimated feed plate composition and not to any error caused by the use of the absorption factor.

This comparison of the absorption factor method with the rigorous stepwise calculation indicates that there are two sources of possible error in the application of the absorption factor method as described:

1. Errors in the estimated composition of the feed plate, due to the assumption of linear temperature gradient, and to a greater extent to the improper use of equations 8 and 9. These, or equivalent, assumptions are also employed by all other methods which have been proposed for computing the number of plates for complex mixtures, and errors so introduced are not due to the use of the absorption factor but to these methods for estimating the composition on the feed plate.

2. Errors in the number of plates introduced by applying an arithmetic average for the value of the equilibrium constant, K, to a component which goes through a maximum composition between the terminal plates. Such errors may be avoided by applying the absorption factor to components which do not pass through a maximum concentration, either by selection of the proper component or by selection of segments of the column to avoid maximum composition between the plates used as terminal plates.

If the column is making a sharp separation between two adjacent components and the feed plate is so located as to accomplish this separation in the most efficient manner, the estimated composition of the feed plate is substantially correct, none of the cut components goes through a maximum in that part of the

column where the absorption factor method would be applied, and the method as outlined may be used with satisfactory results.

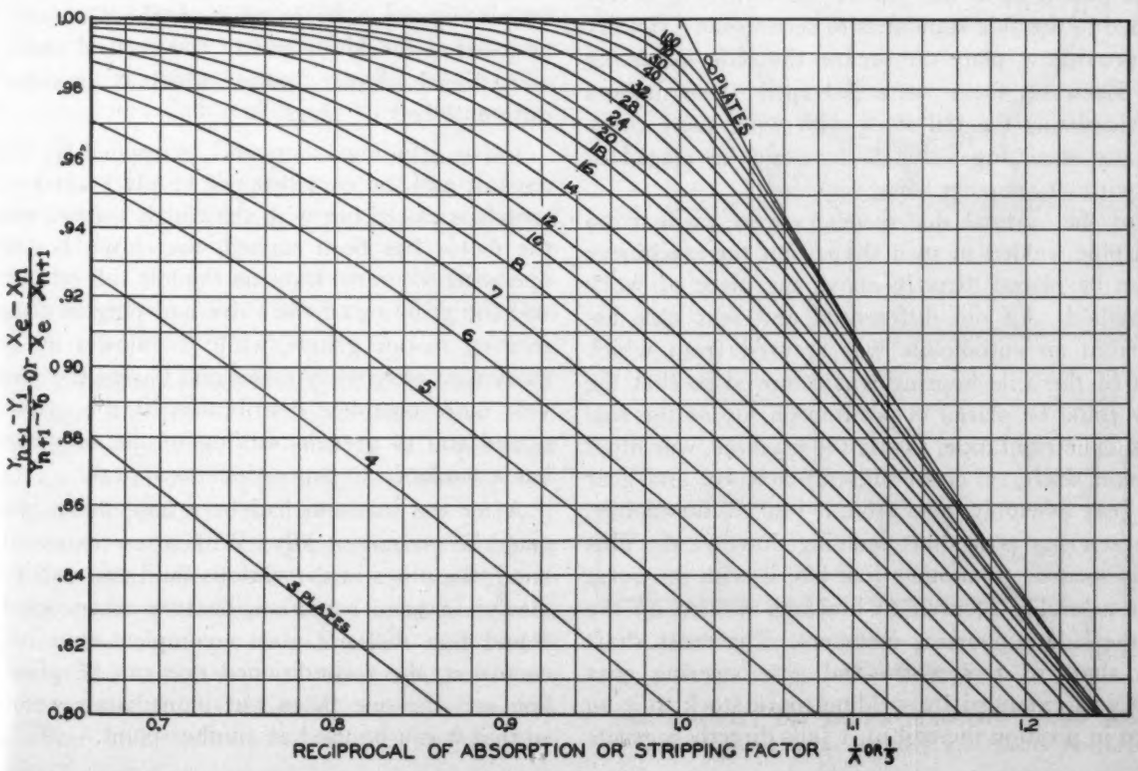
If there are to be three distributed components present in appreciable quantities in both the overhead and the bottoms, as in the case of columns 1, 2 and 3, the estimated composition of the feed plate may be in considerable error unless the ratio of plates above the feed plate to the plates below the feed plate is two or more. In any column in which one component is distributed between the overhead and the bottoms, that is, not reduced to a minimum in either the overhead or the bottoms, the component so distributed is very likely to go through a maximum at some point between the terminal plates. Therefore it is necessary to apply the absorption factor method to another component which is not so distributed, but is reduced to a minimum in either the overhead or bottoms as the case may be, in order to obtain reliable results. This was done in columns 1, 2 and 3 by applying the absorption factor method to propane in the stripping section and pentane in the rectifying section.

In many columns that are apparently making a sharp separation between two adjacent components, the feed plate may be so located that in effect the column is actually distributing one intermediate component between the top and the bottom. In such a case reliable results can be obtained only by applying the absorption factor method to another component which is not distributed. This type of operation is exemplified by column 4 in Table I in which the composition of the tops and bottoms in respect to propane and butane are the same as in columns 5 and 6. But due to the peculiar location of the feed plate in column 4 the column is operating as though it were distributing butane between the overhead and the bottoms. The butane goes through a maximum in the rectifying part of the column and the correct number of plates can be obtained only by applying the absorption factor method to pentane in the rectifying part of the column.

If these difficulties, the equivalent of which are common to all methods, are kept in mind the absorption factor method as outlined should prove a convenient and reliable procedure for the design or calculation of the number of equilibrium plates required for the separation of complex mixtures, provided equilibrium may be expressed in terms of an equilibrium constant as for ideal solutions. *(To be concluded)*

NOMENCLATURE

F = Moles of feed to column; used as subscript to signify feed.
B = Moles of bottom product; used as subscript to signify bottom product.
D = Moles of distillate withdrawn as overhead product; used as subscript to signify overhead product.
V = Moles of vapor rising from plate in rectifying section; used as subscript to signify vapor phase.
L = Moles of liquid overflowing from plate in rectifying section; used as subscript to signify liquid phase.
$\overline{V}$ = Moles of vapor rising from plate in stripping section.
$\overline{L}$ = Moles of liquid overflowing from plate in stripping section.
a, b, c, d, etc., refer to moles of individual components of which a is the most volatile; when used as subscript the letters refer to individual components.
x = Mole fraction of any component in the liquid.
y = Mole fraction of any component in the vapor.
n = Number of theoretical plates above feed plate; used as subscript, refers to any plate in rectifying section.
m = Number of theoretical plates below feed plate; used as subscript, refers to any plate in stripping section.
f = Feed plate, i.e., plate from which the vapor rising becomes the feed to the rectifying section and liquid overflowing becomes the feed to the stripping section.
1, 2, 3, etc., refer to the first, second, third, etc., plate of the column, numbering from the top downward.
K = Equilibrium constant for a particular component.
A = L/KV = absorption factor for a particular component.
$S = \frac{K\overline{V}}{\overline{L}}$ = stripping factor for a particular component.



Home-made Plug Valve Core Grinder

BECAUSE of the sulfur compounds contained in the crude corroding gates, valves and other equipment used in controlling the flow of the various products manufactured, Joe Dockwiller, general foreman for MacMillan Petroleum Corporation at Borger, Texas, designed and built a plug valve grinder that is not only speedy but will accommodate any size of the plug valves used in that plant. Considerable thought was given to the design of the grinding apparatus and after the idea had been reduced on the drafting table to working drawings, it was necessary to do a large amount of machine work in the shop on the different parts so that they would synchronize during the actual grinding operation.

Practically all of the different parts used in building this machine were salvaged from junked lathes, automobiles and from the plant scrap pile, except a small electric motor which was purchased. The subframe was constructed by using angle iron for the legs which set on blocks in front of the shop work bench. A sheet of boiler plate was welded to the top of these legs and to short ones resting on the back of the bench, making a rigid table for valves to be placed upon and to which the upper part of the machine as well as the back braces could be welded.

A narrower sheet of boiler plate was welded to the inside of the front legs and to the outer rim of the table. Two more pieces were welded to this sheet to which the plug body supporting device was secured. A yoke was placed upon the top of the centering device and welded to the side standards to secure more rigidity and to provide a place to secure the side adjusting points. Each of these were salvaged from junked lathes, remodeling the tail stock with wide angle cones so that any size plug valve body could be placed in position without adapters being required.

Each of the vertical side members were made from two-inch pipe welded in such shape that the machinery above can be placed directly above the piece of work being handled. An old differential and rear axle assembly from an automobile was secured from which sufficient of the axle housing was removed so that the assembly could be placed in position on top of the side members. The right axle, facing the machine, was fitted to the main shaft, or cross shaft of a worm and gear steering gear assembly, also from a junked automobile, with the steering post shaft hanging downward. This shaft was secured to another just like it with its worm and gear assembly secured to brackets welded on the side of the side supporting members. The cross shaft or main shaft of this worm and gear steering gear assembly was extended by welding more stock to it so that when in position the end of it falls directly opposite the center of the machine. A cam was machined and placed on the end of this shaft with an apparatus yoked to the cam to provide an up and down motion to the driving shaft attached to the valve core.

The axle shaft on the left side of the machine was cut apart and a clutch was placed on the two stubs so that the machine could be stopped and started without operating the switch on the wall back of the assembly. The small electric motor was placed above this clutch on a plate welded to the top of the side members. It was fitted with a gear meshing with a larger one attached to the outer, or extreme left end, of the severed axle shaft. Power being furnished by the motor, it is transmitted through the reduction gear to the stub shaft with the clutch attached. When in operation, the axles of the differential assembly turn through the differential, and also drive the ring gear which in turn (being meshed with the old drive pinion) causes the drive shaft to rotate.

The lower end of the drive shaft was machined with a sleeve so that the shaft attached to the core can be raised and lowered as the action of the cam is applied through the yoke. This movement was designed in the machine, in addition to the rotating movement, to raise and lower the plug in the body to provide a better job of grinding than if continuous pressure were applied while it was rotating.

To operate the machine, the plug valve body is placed on the supporting member in the center, and the centering tools of the two tail stocks are run into the body so that an exact centering is provided. The supporting member having a screw adjustment with a wheel on the lower end, is run up against the bottom of the plug valve body so that its weight is removed from the two side centering tools. After centering has been secured by placing the body in position, the plug—or core—is attached to the lower end of the vertical shaft through a machined adapter, one of which is provided for the different sizes of plugs.

Valve grinding compound is applied in the proper amount and the core dropped in place after which the switch is closed but with the clutch thrown out. When the motor has been started, the clutch is engaged by operating a control lever on the left side of the machine and the grinding of the valve and plug has begun. The rotating motion grinds, while the slower up and down movement alternately raises and lowers the plug to provide more complete distribution of the grinding compound and to prevent scoring of the two faces which has a tendency to cause rings to appear.

After the machine had been assembled, plug valves could be ground rapidly. With a few extras always on hand, the plugs in the various fluid and vapor lines are always in good condition, because when one has been found that will not give a complete shut off, due to corrosion, the reconditioned one can be placed in the line and the one taken out immediately reconditioned so that it can be used at another point.

Testing and Repairing *Orifice Meters*

RUSSELL M. LILLY

ORIFICE meter testing, repair, and adjustment is usually done directly at the meter setting in the field in spite of the obvious disadvantages attending this practice.

Meters are often set in entirely open surroundings, completely exposed to sub-zero winter blizzards, scorching summer suns or wet and stormy weather. The difficulties encountered in testing and repairing instruments under these adverse conditions are such that meter-men are not to be censured for their inclination to postpone tests and repairs until the return of more favorable working conditions. Indeed, they are not generally expected to do otherwise.

Such delays, however, are expensive due to erroneous chart recordings and mechanical injuries aggravated by neglect. Furthermore, they have no place in any efficiently operated business.

There is now a tendency to adopt what might be termed a "quick-change interchangeable" meter installation. All instruments are set up in exactly the same manner and in such a way that they are easily interchangeable with one another or with "spares." When a meter is reported bad or suspected to be out of commission, the chart reader immediately notifies the repairman, who drives to the setting, quickly removes the defective instrument and replaces it with one in good working order.

This procedure allows the meter to be cleaned, serviced and tested in an adequately sheltered and equipped repair shop, thereby putting to a definite end any excuse for delay or sloppy workmanship occasioned by half frozen fingers in the winter and blistering hot metals in the summer.

The "quick-change" meter is subject to several variations of design, but one of the most simple and inexpensive is that illustrated in Figure 1. It requires as additional equipment not more than one quarter-inch and one two-inch union over and above that usually used in a meter installation. The quarter-inch pipe unions on the upstream, downstream and static pressure connections are placed close to the meter body with short nipples, and eight- or 10-inch nipple and a two-inch union on the metter support completes the set-up. Disconnecting these unions allows the meter to be completely removed and replaced in a matter of five minutes or less. Upon removal, it is advisable to plug with small cork or rubber stoppers the entrances to the float chamber in order to prevent the possible loss of mercury during transportation.

The "quick-change" installation should go hand-in-hand with adequate tools and equipment for testing and repair. Figure 2 illustrates an inexpensive meter repair bench with a built-in test setting. This setting consists of a two-inch standard iron pipe, extending at least

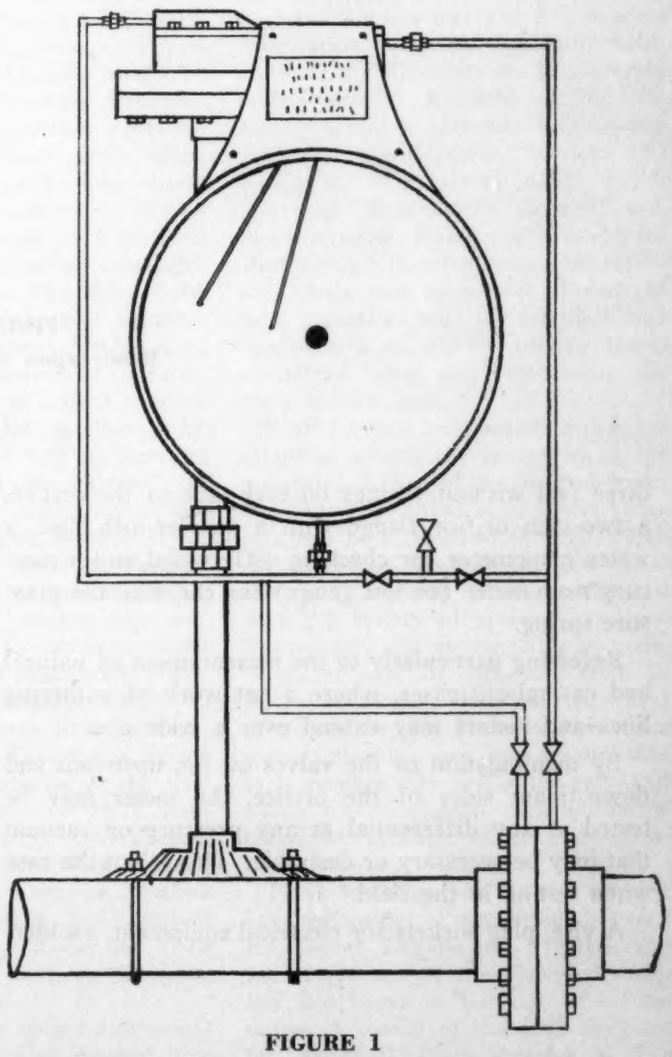


FIGURE 1

Disconnecting the unions illustrated above allows the instrument to be quickly and easily removed.

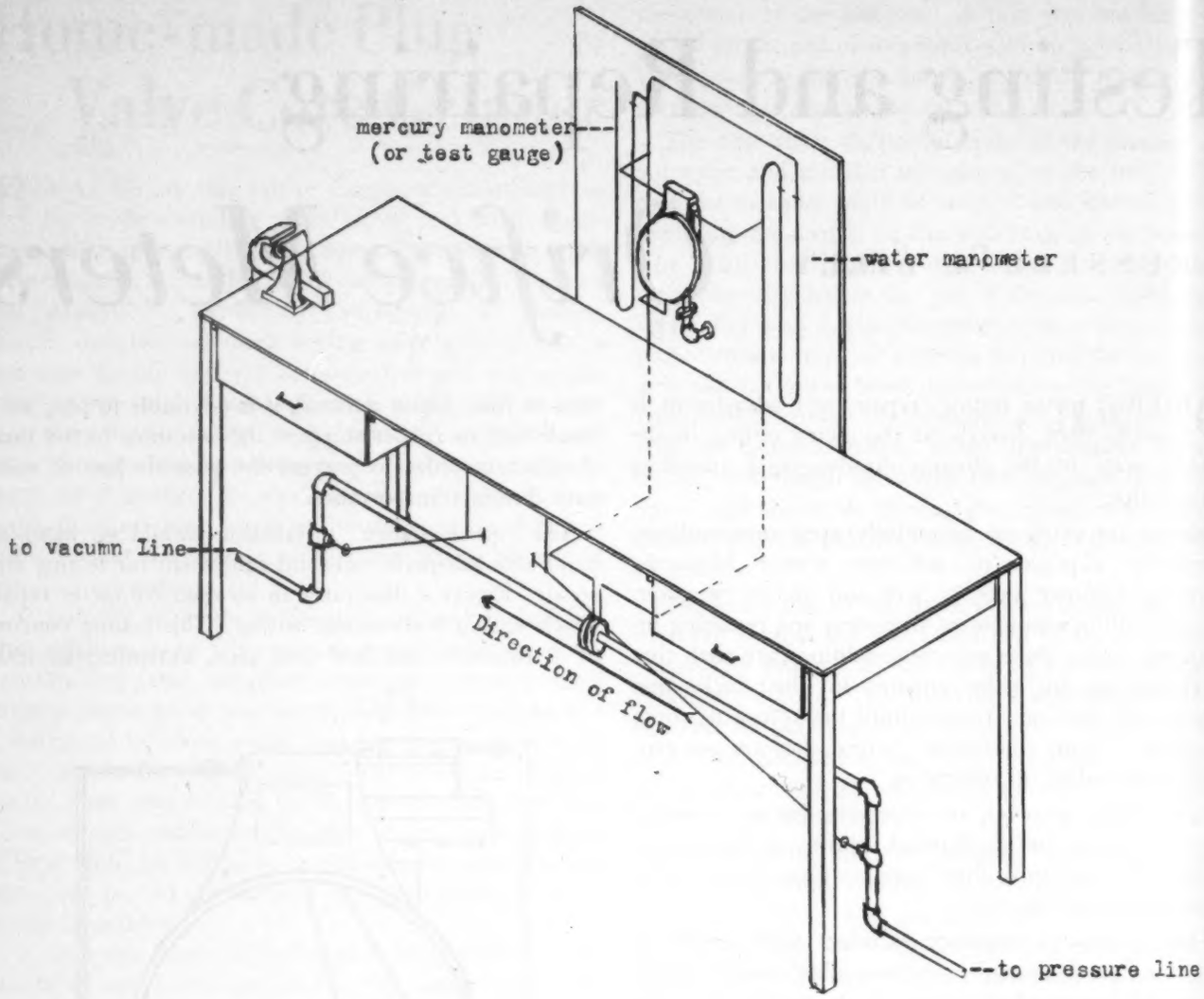


FIGURE 2
Meter repair and test bench.

three feet without fittings on each side of the orifice, a two-inch orifice flange with a quarter-inch disc, a water manometer for checking differential and a mercury manometer (or test gauge) for checking the pressure spring.

Referring particularly to the measurement of natural and casinghead gases, where a net work of gathering lines and meters may extend over a wide area:

By manipulation of the valves on the upstream and downstream sides of the orifice, the meter may be tested at any differential at any pressure or vacuum that may be necessary or desirable. This is not the case when testing in the field.

A vise, plug sockets for electrical equipment, (soldering irons, drills, etc.), an air hose for pressure cleaning and other useful accessories that would not be available in the field will aid greatly in effecting cheap, quick and efficient repairs.

The use of this equipment encourages the periodical examination and overhaul of instruments. For example, a small natural gasoline plant with 25 meters brings in and completely cleans, repairs, tests and paints one meter each week. In other words, each instrument gets a general overhaul and testing at least two times per year. Under the old order it would have been lucky to get a complete working over one time every two years.

(*Continued from page* 138)

some 182,000 other taxing units. It must employ auditors to go over its books to determine how much is owed the respective taxing units, and it must employ tax experts to prepare the numerous and complicated tax returns.

In states where it is obligatory to install signs showing the price of tax and gasoline, this provision adds to the expense of collecting the tax. Such signs cost one company more than $5000, and the expenses of distributing and installing them exceeded this amount.

The oil industry is spending large sums to prevent tax evasion, from which governmental units reap all the benefits. In one state where the industry spent $20,000 in combating evasion, a return of $300,000 accrued to the state.

The duties of a large part of the personnel of the industry are affected by the cooperation rendered in collecting the tax. Among those whose duties are affected are the service station salesman, and tank truck driver, the field supervisor, and the accounting, auditing, tabulating, tax, legal, and executive departments.

"The oil companies, as trustees of gasoline tax funds must pay the tax to the state whether or not they receive payment for the sales of their product," the report asserts. "The industry bears the loss when these 'trust' funds in company hands are lost, as occurred during the banking crisis of 1933."

Boggs Elected to Head Western Refiners

DETRIMENTAL effects to the petroleum industry if the revised National Industrial Recovery Act becomes law as now written were outlined by Fayette B. Dow, Washington counsel for the Western Petroleum Refiners Association at its annual meeting at Excelsior Springs, Mo., April 4 and 5.

The impression given out in Washington is that the proposed bill is but an extension of the National Industrial Recovery Act. You can see by this comparison, stated Dow, that the measure under consideration is something far different

The Look Box

from an extension of law already on the statutes.

Furthermore, this bill would leave it possible to force the petroleum industry into the classification of a public utility. We have had threats of that from Washington but authority does not exist for it. With adoption of this measure as offered by the administration, authority would exist for that move. Dow discussed refusal of the attorney general to press the Belcher case as a test of NRA before the Supreme Court. He said the proposed measure sought to correct points which made this case weak from the viewpoint of the government. This bill, he added, contains the first legislative reference to a code authority. Furthermore, under its provisions organizations within an industry would cease to hold power allowed under the present bill. The Planning and Coordination Committee, for instance, would be relegated to merely an advisory capacity, since no final discretionary power could be delegated to an organization composed in whole or in part of persons within the industry under control.

The threat of public utility classification for the petroleum industry exists under authority which this measure would grant the President provided he should find it necessary to promote or sanction devices for price fixing or controlling production under five sets of conditions. One of the five reads: "To those trades or industries which are not or hereafter subjected to governmental regulation of prices, services and methods of operation as public utilities, or as natural resource industries, (such as among others, coal, oil or gas) or because they are found to be affected with a public interest." In considering this Dow said: "Oil is specifically mentioned as an industry of the type that may be so classified. Furthermore the lawyers know that the words affected with a public interest apply only to public utilities. There can be no doubt that this is a threat of public utility classification for the petroleum industry."

C. N. Boggs, Kanotex Refining Company, Arkansas City, Kansas, was elected president of the association at the final session. Vice presidents are H. T. Ashton, Lubrite Division Socony-Vacuum Oil Corporation, St. Louis; Roy B. Jones, Panhandle Refining Company, Wichita Falls; R. W. McDowell, Mid-Continent Petroleum Corporation, Tulsa, and T. H. Barton, Lion Oil & Refining Company, El Dorado, Arkansas.

The annual meeting opened with memorial service in memory of Howard Bennette, Tulsa, president, who died March 10 at Rochester, Minnesota.

Engineering Societies to Meet Jointly May 20

OFFICERS and directors of the national societies of civil, mining and metallurgical, mechanical, and electrical engineers, and of their several jointly sponsored functional organizations will all meet together for dinner Monday, May 20, at the Engineers' Club in New York, according to plans recently announced by United Engineering Trustees, Inc., acting for the societies in sponsoring the proposed meeting. This is the first time any such meeting has been undertaken and it is considered to be an important step toward establishment of a broader and clearer understanding of the scope of work carried on jointly by the several participating societies.

A wide variety of technical and other activities of importance to every branch of engineering has been carried on by the agencies jointly created and sponsored by the engineering societies: United Engineering Trustees, Inc., and its two departments, The Engineering Societies Library and The Engineering Foundation; American Standards Association; the Division of Engineering and Industrial Research of the National Research Council; Engineering Societies' Employment Service, and Engineers' National Relief Fund; American Engineering Council; and, more recently, Engineers' Council for Professional Development. The activities, ideals, and procedures of each of these agencies will be described and explained concisely by society representatives long associated with the work in each case.

With a better understanding thus established among the personnel of the governing bodies of the several societies, it is hoped that more direct channels will be established through which the individual members of the societies may become better acquainted with the variety of professional services actually directly available to them. This, in turn, is important from at least two angles: first, in order that each member may know how to make use of these services, and second, that each member may realize the extent to which his own small contribution is magnified through effective cooperation.

Plans for this joint dinner meeting have grown out of discussions between the United Engineering Trustees and the secretaries of the Founder societies that began in January. The committee in charge of the affair includes Dr. Alfred D. Flinn, director of The Engineering Foundation, chairman; H. V. Coes, president of United Engineer-

ing Trustees, Inc., honorary chairman; George T. Seabury, secretary, American Society of Civil Engineers; A. B. Parsons, secretary, American Institute of Mining and Metallurgical Engineers; C. E. Davies, secretary, American Society of Mechanical Engineers; H. H. Henline, secretary, American Institute of Electrical Engineers; and John Arms, secretary, United Engineering Trustees, Inc.

New Members Tanker And Barge Committee

D. V. STROOP, secretary of the Central Committee on Tanker and Barge Transportation Committee of the American Petroleum Institute has announced the appointment of H. A. Gilbert, Oil Transfer Corporation; Charles Kurz, Pennsylvania Shipping Company; and C. D. Mallory, C. D. Mallory, Inc., to membership on that committee.

La.-Ark. Refiners Association Meet

THE Louisiana-Arkansas Refiners Association, Technical Division, held its regular monthly technical session at Shreveport, Louisiana, Friday, March 15. Representatives of about twenty refineries in this district were present. At this meeting the topic for study was cracking, following presentation of the paper, "A Discussion of the Factors in Cracking," by A. W. Trusty, chief chemist, Louisiana Oil Refining Corporation, Shreveport.

Rebate Four Cents Of Louisiana Tax

A SPECIAL session of the Louisiana Legislature that adjourned March 2 passed a resolution empowering the Governor of Louisiana to adjust the five cents per barrel refinery tax as the governor "deemed expedient."

Pursuant to that resolution Governor O. K. Allen announced that he would rebate four cents of the five cents tax. The tax had been levied at a previous special session last December and was to have gone into effect January 9 this year. Later the state administration announced that for 90 days after January 9 four cents of the five cents tax would be rebated provided refineries took four-fifths of their crude from Louisiana oil.

It had been hoped that the tax would be lifted at the special session adjourning March 2 but this was not done, the rebate resulting instead.

The present arrangement is far from satisfactory as the rebate can be cancelled at any time within a 30-day period by the governor, and refiners are therefore unable to estimate their costs of production.

Petroleum Prices Below Normal

WHOLESALE prices of petroleum products were less than 50 percent of normal at the end of 1934, far lower than any other group of commodities listed by the Department of Labor in its monthly wholesale commodity price index, based on prices in 1926 taken as normal.

Textile products, next lowest to petroleum, were 70 percent of normal during the last month of the year. The prices of metals and metal products were the highest, being 85.9 percent as high as they were during 1926, while building materials and hides and leather products followed at 85.1 percent.

Prices of the principal groups listed in the index are given in the accompanying table:

Groups	Dec. 1934	Dec. 1933	Dec. 1931[1]
All commodities	76.9	70.8	68.6
Farm products	72.	55.5	55.7
Foods	75.3	62.5	69.1
Hides and leather	85.1	89.2	79.8
Textiles	70.	76.4	60.8
Fuel & lighting materials	73.7	73.4	68.3
Metals & Metal products	85.9	83.5	82.2
Building materials	85.1	85.6	75.7
Chemicals and drugs	78.1	73.7	76.1
Housefurnishing goods	81.2	81.	78.5
Petroleum products	49.8	51.6	39.6

[1]The year 1931 represented the low point in commodity prices for many industries.

Conventions

P. I. E. A. The Petroleum Industry Electrical Association will convene at the Hotel Baker, Dallas, Texas, April 11 to 13.

N. P. A. The National Petroleum Association will hold its semi-annual meeting, Hotel Cleveland, Cleveland, Ohio, April 18 and 19.

A. C. S. Beginning April 22, American Chemical Society will hold its semi-annual meeting in New York City.

N. G. A. May 1, 2, 3, Natural Gasoline Association of America will hold its annual meeting at the Tulsa Hotel, Tulsa, Oklahoma.

A. S. M. E. The American Society of Mechanical Engineers, National Oil & Gas Power Meeting, Oil & Gas Power Division, meets at Tulsa, Hotel Mayo, May 8-11.

A. I. C. E. May 14-16, American Institute of Chemical Engineers will meet for its semi-annual convention in Wilmington, Delaware.

A. P. I. American Petroleum Institute will hold its fifth mid-year meeting in the Mayo Hotel, in Tulsa, May 14, 15, 16.

A. S. C. E. The American Society of Chemical Engineers, holds its meeting in Cincinnati, Ohio, June 19-21.

P. G. C. O. A. Pennsylvania Grade Crude Oil Association plans to hold its annual convention at State College, Pennsylvania, June 20 and 21.

A. S. T. M. American Society for Testing Materials annual meeting is scheduled for June 24 to 28 at the Book Cadillac Hotel, Detroit, Michigan.

N. P. A. The National Petroleum Association, September 25-27, will hold its annual meeting at Atlantic City, at Hotel Traymore.

N. S. C. National Safety Council holds the twenty-fourth annual Safety Congress, in Louisville, Kentucky, October 14-18.

A. P. I. The American Petroleum Institute will hold its 16th annual meeting at the Biltmore Hotel, Los Angeles, November 11-14.

C. N. G. A. The California Natural Gasoline Association holds its meeting the first Thursday of every month in the Richfield Building, Los Angeles, California.

Allowable of Crude Oil Authorized for April

A NUMBER of minor changes in state oil production allowables aggregating a total increase of 7000 barrels daily was authorized for April in an order by Oil Administrator Harold L. Ickes. Production for April was placed at 2,527,300 barrels daily as compared with 2,520,300 in March.

The allowable was recommended to Administrator Ickes under the terms of the Oil Code by the Bureau of Mines and the Petroleum Administrative Board, and concurred in by the Planning and Coordination Committee representing the petroleum industry under the Code.

The changes which were in the nature of minor corrections to meet practical working conditions follow:

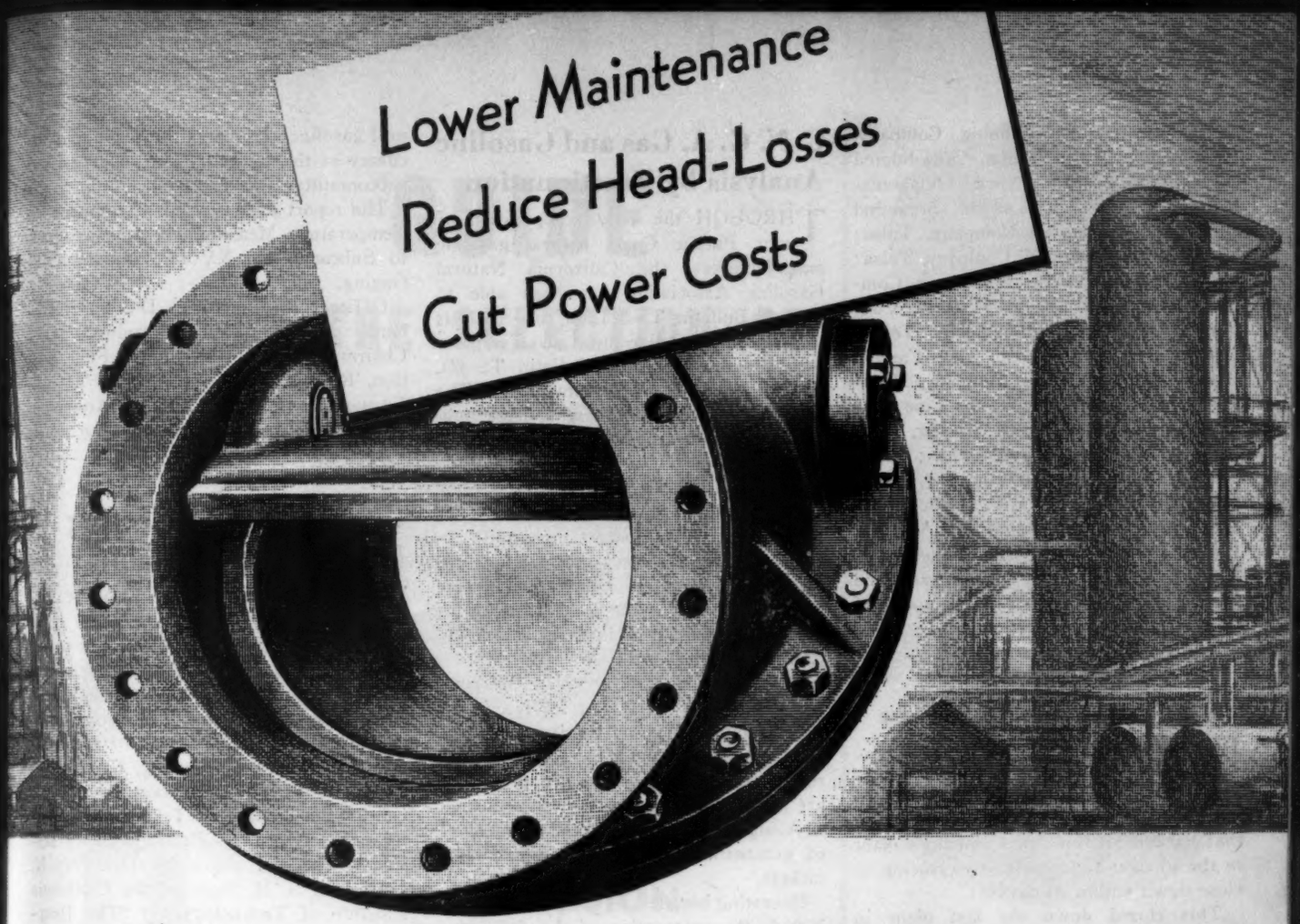
Arkansas, off 1200 to 30,700; California, up 70 to 493,300; Colorado, up 200 to 3700; Illinois, off 200 to 11,000; Indiana, up 100 to 2300; Kansas, up 1300 to 141,000; Kentucky, up 600 to 15,300; Louisiana, up 500 to 111,000; Michigan, up 1100 to 32,700; Montana, up 200 to 9700; New Mexico, up 400 to 49,700; New York, up 400 to 11,700; Ohio, down 200 to 11,300; Oklahoma, up 2300 to 493,300; Pennsylvania, up 1000 to 44,300; Texas, up 900 to 1,021,000; West Virginia, down 300 to 11,000, and Wyoming, down 800 to 34,300.

Crude Oil Measuring And Testing Committee

O. D. DONNELL, chairman of the American Petroleum Institute's Central Committee on Standard Procedure for Measuring, Sampling, and Testing Crude Oil, has appointed George H. Forster, Union Oil Company of California, Los Angeles, national chairman of the National Sub-Committee of Oil Accountants for 1935.

Other members of the committee appointed by Mr. Donnell include:

Eastern Area: A. M. Brereton, The Pure Oil Company, Chicago; V. L. El-



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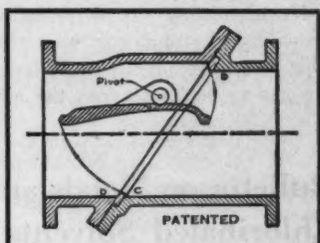
The Chapman Non-Slam Check Valve uses the new principle of the *balanced disc* to set a new top in check valve performance for the oil industry.

The disc of this new valve is supported and *balanced* on two hinge pins. It requires little force to keep it clear of the seat. It does not throw its weight against the stream, but rides lightly and smoothly with the flow. There is no flutter to cause head loss and wear out bearings. And when the valve closes, *it cannot slam*, because of the cushioning effect of the stream against the short flap of the disc.

The advantages of the non-slam balanced disc —and the clear lines of the valve body—have been proved by service records of installations in stabilizer charging lines, cooling tower water lines, compressor and gathering lines and other oil industry applications. Chapman Non-Slam Valves are cutting head losses as much as 75%. They are making substantial reductions in power costs, particularly when installed in pump discharge lines. They are cutting maintenance costs.

Non-Slam valves are furnished in cast iron or cast steel in all standard sizes and for pressures to 1500 lbs. . . . operate equally well in either a horizontal or vertical position on oil, gas, air, steam or water lines. They close drop tight.

A new illustrated booklet describes the many outstanding advantages of the Chapman Non-Slam Check Valves. *Write for your copy today.*



The balanced disc closes quickly and quietly *without slamming*, because of the cushioning effect of the stream against the short flap of the disc.

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liott, The Atlantic Refining Company, Philadelphia; E. L. Wagon, Consolidated Oil Corporation, New York. Oklahoma-Kansas Area: A. L. Carlson, Stanolind Crude Oil Purchasing Company, Tulsa; L. S. Collins, Carter Oil Company, Tulsa; R. M. Riggins, Phillips Petroleum Company, Bartlesville; George F. Smith, Continental Oil Company, Ponca City. Texas-Louisiana-Arkansas Area: Gay Carroll, Humble Oil & Refining Company, Houston; R. J. Daniel, The Texas Pipe Line Company, Houston; L. S. Sinclair, Magnolia Petroleum Company, Dallas; A. M. Smith, Gulf Production Company, Houston. California Area: J. T. Durkee, General Petroleum Corporation, Los Angeles; David Heggie, Shell Oil Company, P. L. Lacombe, Associated Oil Company, and B. W. Letcher, Standard Oil Company of California, all of San Francisco.

Pledger Plant Required to Repressure or Close Down

THE Texas Railroad Commission last Thursday issued an order requiring that Paramount Gasoline Company's plant in the Pledger field begin repressuring or close down within 30 days.

This closed down the last plant in South Texas which is stripping gas and blowing it into the air under a commission permit, according to Commission Chairman Ernest O. Thompson.

In its order the commission said that it had found that the operation of the plant was not in the interest of, or conducive to the public welfare ". . . there are no existing circumstances or conditions which justify the continuance of this practice . . . of blowing the residue or tail gas into the air . . ."

The commission originally issued an order permitting the stripping operations providing the tail gas was repressured. This was subsequently modified to permit the gas to be blown into the air.

Bulletin on Metals and Chlorinated Solvents

BECAUSE of the growing use of chlorinated solvents in oil refining and because of available experience records in the dry cleaning trade with similar solvents, The International Nickel Company's Technical Bulletin TS-7, should prove of interest to those in the refining industry concerned with such problems. The bulletin, "The Resistance of Nickel and Monel Metal to Corrosion by Chlorinated Solvents use for Dry Cleaning," prepared by the development and research department of the above company, is offered free to those who may be interested.

C. N. G. A. Gas and Gasoline Analysis by Fractionation

THROUGH the active cooperation of nine Pacific Coast natural gasoline manufacturers, the California Natural Gasoline Association has been able to publish Bulletin TS-311 on the Analysis of Natural Gasoline by Low Temperature Fractionation, and Bulletin TS-321, on the Analysis of Natural Gas. The material contained in these 15-page publications was arranged by a group which studied the problems of gasoline analysis under the joint direction of C. C. Moore, Jr., of Union Oil Company, and R. R. Crippen, of The Texas Company (California); and a second group which attacked the question of low temperature gas analysis under the joint direction of Moore and H. J. Multer, of Union Oil Company.

Both bulletins give complete information covering specifications for fractionating columns, kettles, heating elements, condenser baths, manifolds, manometers, receiving bottles and thermocouples. Data are also given on annealing temperatures, silvering of glass parts, and the degree of evacuation necessary for the column jackets.

Operating instructions are outlined which include the preparation of the apparatus, introduction of the sample, procedure of analysis, distillation rates, and the calculation and reporting of results. Each bulletin, in addition to eight illustrations, contains a table of the physical constants of the principal natural gas and natural gasoline hydrocarbons. Copies of either publication are available at $1.00 each, postpaid, through the secretary, 1217 Associated Realty Building, Los Angeles.

Committee D-2; Petroleum Products and Lubricants

INTERESTING discussions of a number of phases of its work took place at the meeting of A. S. T. M. Committee D-2 on Petroleum Products at its meeting in Philadelphia during Committee Week, March 4 to 8.

The activities of the American Petroleum Institute Committee on Viscosity Standards and Standardization of Saybolt Viscosimeter Tubes has emphasized the necessity of amplifying and clarifying the text of the Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88-33). Report of the D-2 Subcommittee V on Viscosity, which recommended such revisions, was accepted subject to minor changes.

Subcommittee XXII on Natural Gasoline submitted a revision of Methods D 323-32 T on Vapor Pressure of Natural Gasoline (Reid Method). The revision (vapor pressure of motor and natural gasoline) increases the scope and accuracy of the method. The report of the subcommittee was accepted.

The report of the A.P.I. Committee on Temperature Measurement was assigned to Subcommittee XV on Sampling and Gaging.

Officers of Committee D-2 on Petroleum and Petroleum Products are: Chairman: T. A. Boyd, head, Fuel Section, Research Division, General Motors Corporation; secretary, R. P. Anderson, secretary, Division of Refining, American Petroleum Institute.

C. N. G. A. Fall Meeting Proceedings Available

THE California Natural Gasoline Association has just published the complete proceedings of its annual fall meeting, held November 1, 1934. Reviewing the progress of its technical activities, the report of the morning session contains papers by the chairmen of the committees on Gasoline Testing, Gas Deviation, Analytical Fractionation, Absorption Oil Testing, Charcoal Testing, and Metering. The record of the afternoon session contains a paper by Drs. W. N. Lacey and B. H. Sage, of the California Institute of Technology, on "The Properties of Propane"; a discussion of the "Practical Aspects of the Paper by Drs. Lacey and Sage," by H. N. Wade, consulting engineer; "A New Total Heat Chart for Propane," by E. G. Ragatz of Union Oil Company; and a closing discussion by E. R. Cox, of The Texas Company (California) on "The Physical Constants of Propane."

Printed copies of these proceedings, together with a complete stenotyped transcription of the floor discussion, are available to non-members for 50 cents postpaid, through the Secretary, 1217 Associated Realty Building, Los Angeles.

Fuel Consumption at Refineries in 1933

REPORT of Investigations No. 3270, dated February, 1935, is available through the Section of Publications, Bureau of Mines, Washington, D. C., "Survey of Fuel Consumption at Refineries in 1933," by G. R. Hopkins, Acting Chief Economist, Petroleum Economics Division of the Bureau. This thorough analysis of fuel consumption trends, including all types of refinery fuels, is mailed free upon request. Points of prime interest in this years' survey are the increasing use of refinery gases to 42.2 percent of total heat used, along with decreased consumption of fuel oil (35.1 percent of total heat) natural gas, and petroleum coke.

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Use where high oxidation-resistance is required. Combines high corrosion-resistance with excellent ductility and drawing qualities. Similar to 18-8 but with added silicon. Oxidation-resistance to 1800° F.

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Use where corrosion-resistance and high strength and toughness are required. Oxidation-resistance to 2000° F.

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Use where great strength and toughness are secondary to resistance to sulphur and sulphur gases, hot or cold. Oxidation-resistance to 2100° F.

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Carbon Black Export Association Formed

CARBON BLACK EXPORT, INC., formed for the purpose of exporting carbon black has filed papers under the Export Trade Act, with the Federal Trade Commission. Association headquarters will be at 500 Fifth Avenue, New York.

C. E. Kayser is president and director of the association; Reid L. Carr is secretary and director; F. R. Cantzlaar is treasurer; E. V. Gent, assistant treasurer; Godfrey L. Cabot, Thomas D. Cabot, F. F. Curtze, Oscar Nelson, D. P. Haynes, G. A. Williams, R. H. Eagles, Hans Huber, T. J. Butler and Robert Wishnick, are directors.

Member companies are, United Carbon Company, Charleston, West Virginia; Columbian Carbon Company, New York; J. M. Huber Corporation, New York; Century Carbon Company, New York; Panhandle Carbon Company, New York; Godfrey L. Cabot, Inc., Boston; Texas Carbon Industries, Inc., Sayre, Oklahoma, and The Palmer Carbon Company, Chicago.

Gasoline Allowable For April Announced

THE national gasoline allowable for April was placed at 34,520,000 barrels by Oil Administrator Harold L. Ickes, authorizing a decrease of 1,340,000 barrels for the month from the 35,860,000 barrels in March.

In recommending the allocation, the Bureau of Mines and the Petroleum Administrative Board advised Administrator Ickes that refinery gasoline inventories should be reduced 1,520,000 barrels during April.

District—	Allowed Gasoline Production Barrels	Required Seasonal Inventory Changes Barrels
1. East Coast	5,585,000	—297,000
2. Appalachian	1,535,000	—86,000
3. Indiana-Illinois-Kentucky	5,645,000	—191,000
4. Oklahoma-Kansas-Missouri	5,050,000	—104,000
5. Texas:		
(a) Inland Texas	1,908,000	—166,000
(b) Texas Gulf Coast	6,679,000	—200,000
(c) East Texas	550,000	.....
6. Louisiana-Arkansas:		
(a) Louisiana Gulf Coast including Alabama	1,169,000	+1,000
(b) North Louisiana-Arkansas including Mississippi	643,000	—1,000
7. Rocky Mountain	808,000	—37,000
8. California	4,948,000	—439,000
	34,520,000	—1,520,000

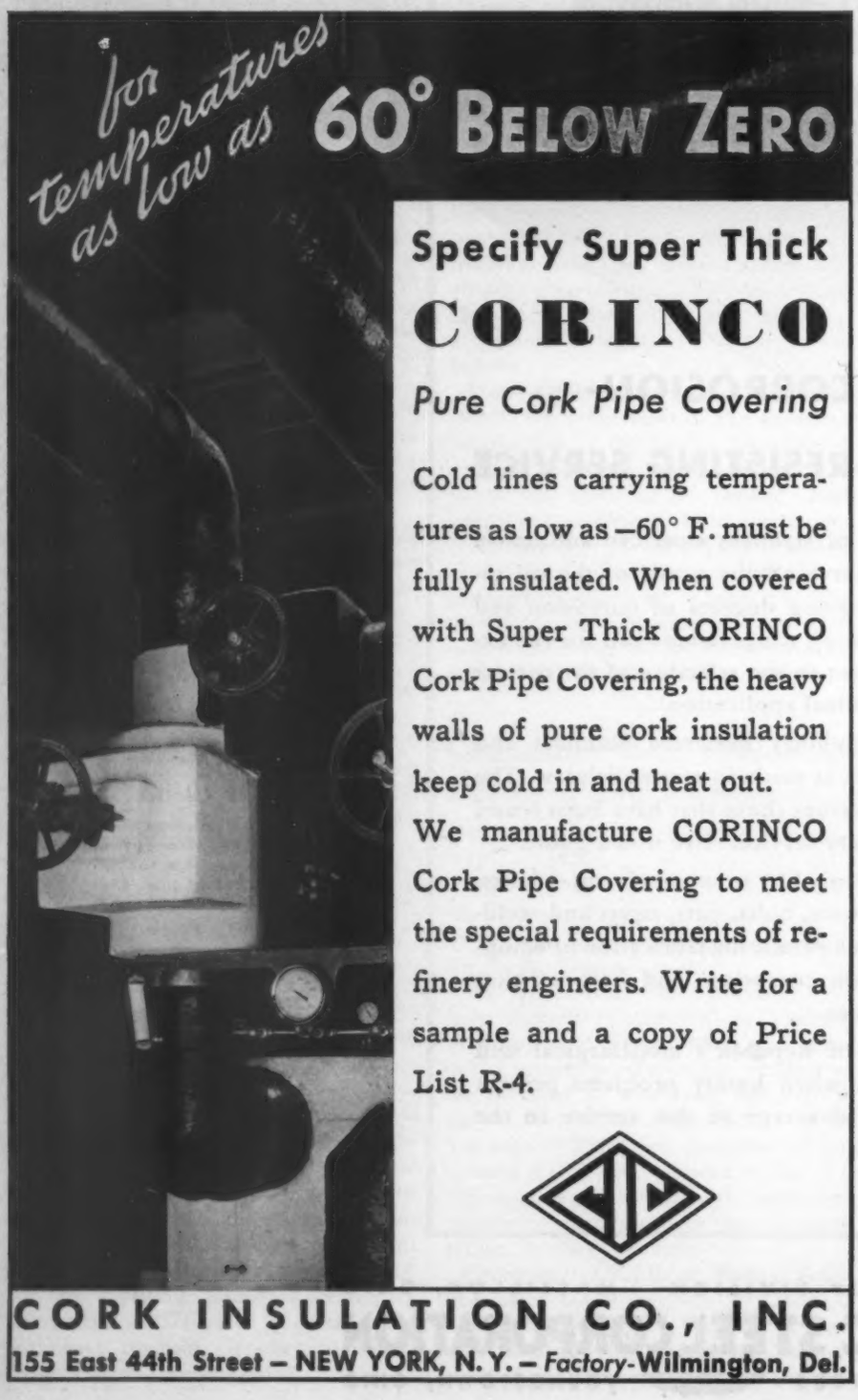
Total United States demand, 36,040,000 barrels.

T. H. WICKENDEN, assistant manager, development and research, The International Nickel Company, has announced addition to the metallurgical staff of Byron B. Morton, formerly plant metallurgist at the Baton Rouge refinery of Standard Oil Company of Louisiana. He will cover the petroleum industries, concentrating on problems involving the use of nickel alloy steels, nickel cast irons, stainless steels and other alloys containing nickel.

ROBERT JACQUEMINET, engineer for the Gironde Oil Refineries, France, is spending some time in this country in the interest of his company.

DORAN MILES has resigned as chemist for the British-American Oil Company, at Coutts, Alberta, and has accepted a position in Vancouver, British Columbia, Canada.

M. L. SNYDER, formerly assistant superintendent, Humble Oil & Refining Company, Baytown, refinery, according to recent announcement by R. E. Powell, general superintendent, has become official representative of the refining department to study refining practices and to handle contacts with other refineries. W. W. Reber, who was manager of the industrial relations department has been appointed assistant chief engineer in charge of construction and mechanical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BOOKS ON PETROLEUM AND REFINING

HEAT TRANSMISSION—*William H. McAdams.*

A comprehensive treatise sponsored by the Committee on Heat Transmission, National Research Council, dealing with the various fields of heat transmission, based on considerable unpublished data as well as on a critical examination of the literature. Contains authoritative correlations for the various important cases of heat transfer with 33 examples of the application of the recommended relations. Published January, 1933. Price, $5.00.

CHEMISTRY AND TECHNOLOGY OF CRACKING—*A. N. Sachanen and M. D. Tilicheyev.*

Published in December, 1932, this book is a valuable addition to the library of those interested in cracking unit design, construction, or operation, or in the general subject of the chemistry or cracking. This late work covers thoroughly the fundamental features of cracking, chemistry of cracking, chemical composition of cracked products, properties and chemical treatment, the principle cracking systems, and includes an excellent chapter on the hydrogenation of petroleum products.

Price $8.00

BUTANE-PROPANE GASES HANDBOOK, Volume 2—Arranged and Edited by *Geo. H. Finley, Editor, Western Gas.*

The second edition of the Butane-Propane Gases Handbook, published February, 1935, is the only work of its kind and presents a most thorough treatment of the liquefied petroleum gases industry. Contents: Summary of Developments, Use in Internal Combustion Engines, Design and Installation of Storage, Supply from Petroleum Refineries, Engineering Data on the Lower Olefins, Domestic Appliance Testing and Utilization, Competitive Position of the Liquefied Gases, Town Plants, Manufacture from Natural Gas, and Special Uses. Supplements and revisions include, Transportation, Use with Other Gases, Analysis and Testing, Properties of Mixtures, Distribution, Bibliography, Central Plant Directory, Catalog Section and Buyers Guide.

Price $5.00

CHEMICAL REFINING OF PETROLEUM —*V. A. Kalichevsky and B. A. Stagner.*

This is American Chemical Society Monograph No. 63, and is a notable contribution to the literature on modern chemical treating practice, covering the subject in a most comprehensive manner. It fills a definite need and the reliable information it contains will be found invaluable for use in every refinery.

Price $7.00

THE CATALYTIC OXIDATION OF ORGANIC COMPOUNDS IN THE VAPOR PHASE—*L. F. Marek and Dorothy A. Hahn.*

The latest work on Oxidation brings the data down to 1932, comprehensively covering the literature dealing with oxidation processes. Contents: Catalysis, Catalytic Decomposition of Alcohols, Oxidation of Alcohols to Aldehydes and Acids, Reactions Involved in the Synthesis of Hydrocarbons and Alcohols from Water Gas, Oxidation of Methanol from Formaldehyde, Oxidation of the Gaseous paraffin Hydrocarbons, Oxidation and Hydration of Olefins and Acetylene, Oxidation of Petroleum Oils, Production of Hydrogen from Methane, Surface Combustion, Knocking in Internal Combustion Engines, Oxidation of Benzene, its Derivatives, Naphthalene Anthracene and Miscellaneous Polynuclear Compounds, Apparatus.

Price $9.00

LUBRICATING GREASES—*E. N. Klemgard.*

Practical and scientific data on the manufacture and use of lubricating greases, chemical analysis of many commercial lubricants, abstracts from important patents, formulas and processes for grease production. Contents: Manufacture of Cup Greases, Uses, Tests, Analysis and Patents; Soda Base, Mixed Soda-Lime, Sett, Lead Base and Miscellaneous Greases and Compounded Oils; Mechanical Mixtures and the Trend in Grease Research.

Price $5.50

THE SCIENTIFIC PRINCIPLES OF PETROLEUM TECHNOLOGY—*Dr. Leo Gurwitsch and Harold Moore, 1932 revised edition.*

The original translation of Gurwitsh's second edition (1925) appeared in 1926, and in response to a wide appeal the preparation of a second edition was undertaken by Harold Moore and C. I. Kelly, to include data on technical and scientific work on petroleum to 1932. The well known standard reference work is the most comprehensive treatment of petroleum technology now available.

Price $9.00

CHEMISTRY OF PETROLEUM DERIVATIVES—*Carleton Ellis.*

This book, published in May, 1934, is styled by reviewers as a most excellent reference work, and a monumental text book in the field of organic chemistry, with special elaboration of derivatives of aliphatic, naphthene, and unsaturated hydrocarbons isolated from petroleum, and is the most up-to-date book on this important subject. The book with its 1285 pages is encyclopedic in scope, a veritable mine of information for those engaged in utilization of natural gas and petroleum and their chemical derivatives.

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CHEMICAL ENGINEERING, UNIT PROCESSES AND PRINCIPLES—*Edited by John C. Olsen.*

A broad practical treatment of unit processes, selection of best type of equipment for the particular process. Includes the following chapters: Heat and Power, Flow of Heat, Evaporation, Principles of Fractional Distillation, Steam Distillation, Dry Distillation and By-Product Recovery, Filtration, Drying, Electric Heating, Catalytic Heating, Absorption of Gases, Electrolysis, Separation of Solids and Liquids from Gases, Materials, of Construction, Cost, Financing and Location.

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Price $5.00

HANDBOOK OF PETROLEUM ASPHALT AND NATURAL GAS, Revised Edition Bulletin 25, Kansas City Testing Laboratory—*Dr. Roy Cross.*

This well known handbook was revised in 1931 and increased to 865 pages. Material incorporated in the first edition of Bulletin 25 was brought down to date. The following is included: Economics of Gasoline, Transportation Storage and Gaging, Properties of Crude Petroleum, Refining and Cracking of Petroleum, Properties of Refining Petroleum, Fuel Oil, Oil Shale, Asphalt, Natural Gas, Methods of Analysis, Tables, Patents and Publications. Well illustrated by graphs, charts and photographs, and replete with valuable tabulations. . .

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ELEMENTS OF FRACTIONAL DISTILLATION—*Clark Shove Robinson.*

Explains principles of distillation simply and accurately according to best ideas of physical chemistry and chemical engineering. Contents—The Phase Rule, One Component System, Two Component System, More Complex Systems. The Gas Laws, Solutions, Simple Distillation, Fractionation, Rate of Fractionation, Discontinuous Distillation, Design of Continuous Still, The Fractionating Columns, The Condenser, Accessories, Continuous Distillation, Ammonia, Benzolized Wash Oil, Mehyl Alcohol, Ethyl Alcohol.

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work. T. W. Moore has succeeded Reber as manager of the industrial relations department. James Harrop, of the technical service department has succeeded M. L. Snyder as assistant superintendent. Smith D. Turner has taken over Mr. Harrops work in the technical service department. Rand Dyer has been transferred from the industrial relations department at Baytown to the Houston office. R. S. Clark has been appointed assistant to O. E. Voss, chief engineer, at the Houston office. M. J. Mattenhemer succeeds R. S. Clark as assistant to J. L. Finley, manager of the refining department, Houston.

WILLIAM F. LOWE, secretary of the Natural Gasoline Association of America, left Tulsa, March 10, for Washington, D. C. In returning he will visit Chicago and Ann Arbor, Michigan, in the work of completing plans for the annual convention of the association, May 1-3.

ALVIN A. BURTON has received the Ph.D. degree from the University of Illinois and has accepted a position in the Research and Development Department of the Standard Oil Company of California, Richmond.

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Gulf Coast Refineries Are Rehabilitating Equipment

CONSTRUCTION and rehabilitation work, in progress and planned, for oil refineries on the Texas Gulf Coast, will involve expenditures of several millions of dollars.

Two outstanding projects will be those of The Texas Company at Port Arthur and of the Pan American Refining Corporation (Standard Oil Company (Indiana) subsidiary) at Texas City.

It is reported that The Texas Company contemplates spending around $3,000,000 on its refinery at Port Arthur. Of that total, about one third will go into installation of a solvent refining plant for lubricating oils, it is indicated. The remainder will represent general modernization and rehabilitation work.

Pan American Refining Corporation, it is understood, will double the capacity of its relatively new refinery at Texas City, which at present can process about 30,000 barrels of crude daily. The plans contemplate increasing the capacity through installation of another combination cracking and distillation unit.

Eastern States Petroleum Company of New York, has leased and will begin operating the plant of Deepwater Oil Refineries, on the Houston ship channel. The Eastern States concern is a large fuel oil and furnace oil distributor in the New York area. Hitherto the Cullinan interests have been running crude for the company at Houston.

Petroleum Conversion Corporation of New York is planning to rehabilitate its plant at Texas City into a 2000-barrel per day refinery. The plant has been idle for about 10 years.

Gulf refining Company at Port Arthur is planning to begin important modernization work in various departments and reports are current that construction work will begin on a new modern solvent refining system soon. Contracts for 14 new pressure tanks have recently been placed.

Shell Petroleum Corporation is likewise reported planning important improvements involving an expenditure of around $200,000 at its Houston plant. Sinclair Refining Company also at Houston is reported contemplating some major improvements and additions. Humble Oil & Refining Company, at the Baytown refinery, has been investigating various solvent refining and solvent extraction processes with a view to enlarging the lubricating oil manufacturing department.

W. F. CEREGHINO, superintendent of refineries for Shamrock Oil & Gas Company, has recovered from injuries sustained in an automobile wreck last fall and is again on active duty.

▼ PLANT ACTIVITIES ▼

Torbanite Plant: The South African Torbanite Mining and Refining Company, in which British Burmah Petroleum Company, Ltd., is reported to hold a one third interest, has been organized with capital of 750,000 pounds and proposes to work extensive torbanite deposits in South Africa, and will erect a plant in the Ermelo district near Johannesburgh, for oil distillation and refining. It is reported that two low temperature distillation retorts, 150 tons per day capacity, have been ordered.

Carbon Black: United Carbon Company, Monroe, Louisiana, has acquired properties in the Monroe and Richland gas fields, and plans additions to the carbon black plants and natural gas developments. Estimated cost will exceed $100,000.

Gasoline Plant: United Gas Public Service Company at Myrtis, Louisiana, adjacent to its original plant there, is building a new line pressure absorption natural gasoline plant.

Enlarge: Pan American Refining Corporation, Texas City, refinery, again reported planning double capacity of the 30,000-barrel plant through erection of new combination skimming and cracking unit.

Solvent Plant: The Texas Company, Port Arthur, and other plants, contemplates spending around $3,000,000 in the near future on improvements. Approximately one third of this will go for a new solvent refining unit for production of improved lubricating oils.

Lease: Eastern States Petroleum Company, New York and Houston, has leased and will begin operating the plant of Deepwater Oil Refineries on the Houston ship channel.

Rebuild: Petroleum Conversion Corporation, New York, is reported planning reconstruction and modernization of the Texas City plant, which has been idle for several years.

Solvent Plant: Gulf Refining Company, Port Arthur, is reported planning to begin important modernization work in various departments, and is to erect a new solvent refining plant for production of new lubricating oils.

Improvements: Shell Petroleum Corporation at Houston is reported planning important improvements involving expenditures of around $200,000, including this work in the general enlargement and improvement program affecting all of its manufacturing facilities.

Gasoline Pipe Line: Cimarron Valley Pipe Line Company, affiliated with Champlin Refining Company, Enid, Oklahoma, is to build a 250-mile gasoline pipe line to Superior, Nebraska. Size 6⅝-inch seamless welded line, with pump stations at Enin and Hutchinson, Kansas.

Oil Storage: White Star Division of the Socony-Vacuum Oil Corporation at Muskegon, Michigan, is erecting a new $175,000 oil handling plant. Don Glass, engineer in charge. Plant includes warehouse, pump house, office, pipe line, wharf and tankage.

Enlarge: Bell Refining Company, Calgary, Alberta, Canada, double capacity of its refinery to 1500 barrels, through installation of semi-cracking unit and other distillation facilities, including tankage.

Refinery: Marmac Oil Company, H. Eadwrad Swift, president, Winnipeg, Manitoba, Canada, contemplates construction of a refinery at estimated cost of $50,000.

Improvements: Standard Oil Company of California, Richmond, plans to reconstruct several pressure stills at the Richmond plant, at reported estimated cost of $200,000.

Refinery: Consumers Refineries Co-Operative Association, Regina, Saskatchewan, Canada, is reported to have awarded contract to North West Iron Works, Regina, for construction of $40,000 refinery.

Refinery: Asiatic Petroleum Company, with refining project in Java, East Indies, contract to Arthur G. McKee & Company and contractors have taken 175 tons steel plates, shapes and bars.

Tankage: Royal Petroleum Company, Sewaren, New Jersey, has let contract to Chicago Bridge & Iron Works, for three 55,000-barrel tanks, involving 610 tons steel.

Refinery: The Shell Company, of Palestine, controlled by Consolidated Petroleum Company (Anglo Persian Oil Company and Asiatic Petroleum Company) is erecting a refinery at Haifa, Palestine, on the terminus of the Iraq pipe line's southern branch. Capacity 180,000 tons per year.

Refinery: Societa per l'Industria Chimica Minereria Anon, Italiano (Cispa-

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dana) Via E. De Amicis, 47, Milan, Italy, is reported applying for concessions to build two refineries, one with reported capacity of 700,000 barrels per year, and both to be Bossich cracking units. Propose refining Albanian crude. Herr Bender, technical manager, was formerly with Bossich Company, Germany, during development of the Bossich cracking process.

Refinery: Dent, Ltd., Vancouver, British Columbia, Canada, recently organized has purchased 40-acre site on Burrard Inlet and proposes construction of a $250,000 refinery, to start construction early fall, 1935.

Purchase: Great West Refining Company, Regina, Saskatchewan, Canada, has purchased a 500-barrel refinery at Collins, Montana, and is moving plant to Yorkton, Saskatchewan, to enlarge to 1000 barrels. P. M. Withers, vice president, in charge of plant.

Crude Unit: Texas Oil Products Company, Gladewater, Texas, has completed construction of a new crude skimming unit. Reported capacity of this plant is now 3500 barrels daily.

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Cracking Unit: Lone Star Refinery Company (Trinity refinery) Gladewater, Texas, has completed construction of a new cracking unit. Plant capacity now reported at 6000 barrels.

Improvements: Acme Refining Company, Gladewater, Texas, has completed enlarging capacity and addition of new bubble tower, increasing capacity to 2000 barrels per day.

Cracking Unit: Shell Petroleum Corporation is to erect a new cracking unit at Wood River, Illinois. Late reports indicate contracts for 180 tons of steel for this purpose, pending.

Cracking Unit: The Atlantic Refining Company, Philadelphia, is reported planning erection of new cracking facilities. Late reports state contract for 150 tons of steel pending.

Gasoline Plant: Eason Oil Company, Enid, Oklahoma, is increasing capacity of its gasoline plant in the Crescent pool, western Logan County, by addition of two 265-horsepower twins and one 80-horsepower single compressor units.

Refiner: Fern Oil Company, Thermopolis, Wyoming, is enlarging capacity of the recently constructed refinery from 2500 to 7500 barrels per day. New distillation units and three new 100-horsepower boilers are being installed.

Gasoline Consumption Approached 1931 Record

GASOLINE consumption in the United States in 1934 amounted to 16,617,050,000 gallons, according to preliminary figures prepared by the American Petroleum Institute. This is within 5,000,000 gallons of the all-time high for consumption established in 1931, when 16,621,104,000 gallons were used.

There was an increase of 1,178,726,000 gallons, or 7.63 percent in the amount of motor fuel consumed over the previous year of 1933, every state in the Union showing an increase, although the District of Columbia recorded a drop.

Baird H. Markham, director of the American Petroleum Industries Committee of the Institute, attributes a part of the increase registered to better gasoline tax enforcement on the part of the states, since only the gallonage taxed is recorded.

New York motorists consumed more gasoline than those of any other state, a total of 1,577,019,000 gallons. The next largest amounts of gasoline were consumed in California, Pennsylvania, and Illinois.

P. & C. Committee Re-Elects Officers

THE Planning and Coordination Committee elected officers for the period from March 16, to June 16, 1935, at its meeting Tuesday, March 12. The committee made no changes in its officers. They are: J. D. Collett, chairman; Henry M. Dawes, treasurer; Fred A. Van Covern, assistant treasurer; Irwin Lamp, secretary, and John M. Cameron, assistant secretary.

DR. FREDERICK D. ROSSINI, of National Bureau of Standards, Washington, D. C., has been appointed director of the American Petroleum Institute Research Project 6 on the Isolation and Identification of Hydrocarbons in Petroleum. This project was formerly directed by the late Dr. E. W. Washburn.

A. G. PETERKIN, JR., formerly development engineer, The Atlantic Refining Company, has become a member of the technical staff of Rohm & Haas Company, with headquarters in Philadelphia.

W. G. SCHARMAN is on temporary assignment with the International Hydro Engineering Company at The Hague. His permanent position is that of chemical engineer with the Standard Oil Company of Louisiana at Baton Rouge.

EMORY M. SKINNER, chief engineer, Rock Island Refining Company, Duncan, Oklahoma, for the past four years, has accepted a position with the White Eagle Division, Socony-Vacuum Oil Corporation, at Augusta, Kansas, where he is process engineer. He received his Bachelor of Science degree in Chemical Engineering from Oklahoma A. & M. in 1925, and his Ph.D. in chemical engineering from University of Michigan in 1928. His former connections in the industry included, research laboratory, Pierce Petroleum Corporation, Sand Springs, Oklahoma; Natural Gasoline Department, Skelly Oil Company, and Director of Research, Smith Engineering Company, Kansas City, Kansas, 1928 to 1931. From here he went with Rock Island Refining Company.

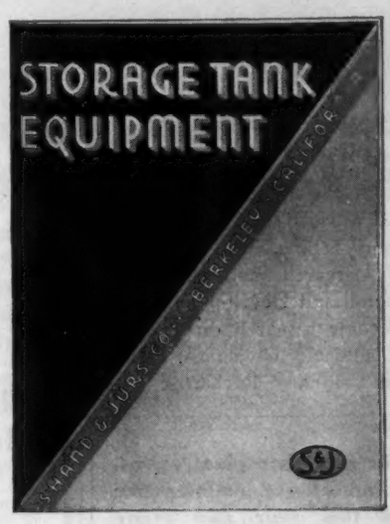
EMORY M. SKINNER

C. E. Townsend to Head Fire Prevention Committee

R. E. HAYLETT, chairman of the American Petroleum Institute's Central Committee on Refinery Technology, has appointed C. E. Townsend, Sun Oil Company, Philadelphia, chairman of the Institute's Committee on Fire Prevention in Refineries. D. V. Stroop, American Petroleum Institute, New York, remains secretary.

Others appointed by Mr. Haylett to the committee for 1935 include:

M. B. Anfenger, Standard Oil Company of California, San Francisco; C.



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ALBERT G. LOOMIS has resigned as advisory fellow, Mellon Institute of Industrial Research, and chief chemist, Gulf Research and Development Corporation, to become research director of Columbia Chemical Division, Pittsburgh Plate Glass Company, Barberton, Ohio.

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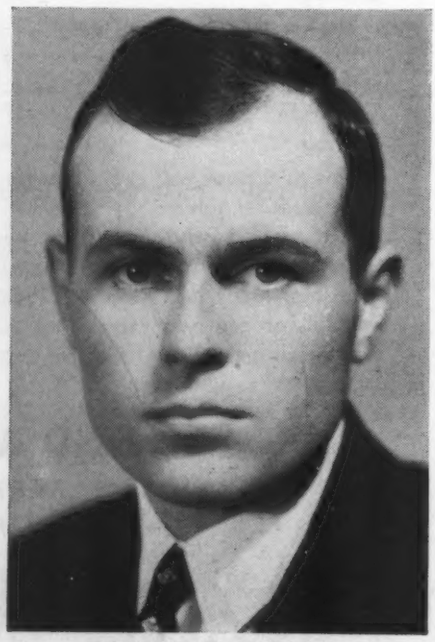
DR. R. P. ANDERSON, secretary of the Committee on Testing Methods and Specifications of the Division of Refining of the American Petroleum Institute has announced the resignation of A. R. Lange, Swan-Finch Corporation, from membership on that committee.

Stainless Iron As Valve Trim Material

ONE of the satisfactory materials for valve trim and seats subjected to high temperatures and pressures is a low carbon stainless iron, containing around 12 percent chromium, according to a correspondent. This material, it is said, has excellent resistance to corrosion under conditions of service encountered in power piping, as well as being unaffected by sulfur bearing oils under conditions of cracking service in refineries. It has good resistance to wire drawing by steam. Being susceptible to heat treatment, it can be hardened to a degree which resists indentation or scoring by foreign matter. When properly hardened it has all the qualifications for a good seat material. When used in combination with copper-nickel-tin and cobalt-chromium-tungsten alloys, it is said to make an excellent material for power plant and refinery service.

Chapman Valve Opens Houston District Office

The Chapman Valve Manufacturing Company, Indian Orchard, Massachusetts, has opened a branch sales office in Houston, to serve the Gulf Coast region, in charge of Robert F. Maher, with offices at 1507 Petroleum Building. Mr. Maher will handle sales on Chapman Valves in this district to both the refining and production branches of the industry.



ROBERT F. MAHER

Crucible Steel Company Forms Petroleum Division

CRUCIBLE Steel Company of America has announced the formation of a petroleum division to handle the sale of all steels used in the production, refining, and marketing divisions of the petroleum industry, as well as to the equipment manufacturers.

W. George Johnson has been appointed manager of the petroleum division, and will operate from the general office of Crucible Steel Company of America located in the Chrysler Building, New York City.

W. GEORGE JOHNSON

Mr. Johnson has been with Crucible Steel Company for several years serving as sales metallurgist confining a greater part of his activities to the introduction and sale of the corrosion resistant, heat resistant, and high strength alloys, particularly to the petroleum industry.

With a division devoted exclusively to the development, sales, and servicing of the many steels used by the oil industry direct and through the equipment manufacturers, and with a personnel augmenting the regular sales force throughout the country, it is expected that better cooperation and results will be obtained for all concerned.

G. H. STILLMAN, formerly with Girdler Corporation, Louisville, Kentucky, is with Gulf Oil Corporation, Pittsburgh.

D. F. JURGENSON, JR., has been appointed chemist in the research and development laboratory of The Pure Oil Company, and is stationed at Winnetka, Illinois.

BUSINESS NOTES

PLIBRICO Jointless Firebrick Company, Chicago, announces that Boiler Engineering Company, Newark, N. J., former builders of Beco-Turner baffle walls for furnaces, has discontinued business and that in the future the Beco-Turner baffles will be installed by this company. The engineering and installation personnel of Boiler Engineering Company has been added to the Plibrico boiler setting department.

R. T. DINWIDDIES has resigned as maanger of the refractories division of The M. W. Kellogg Company, New York, to become vice president of Refractory & Engineering Corporation, 381 Fourth Ave., New York. In this position he is in charge of sales of the company's complete lines of refractory cements and insulations.

A. G. KOENIG, southwestern manager for C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y., is located in the newly opened branch office at 1916 Jackson Street, Dallas, Texas. This branch takes the place of the company's Shreveport, Louisiana, office, which has been closed.

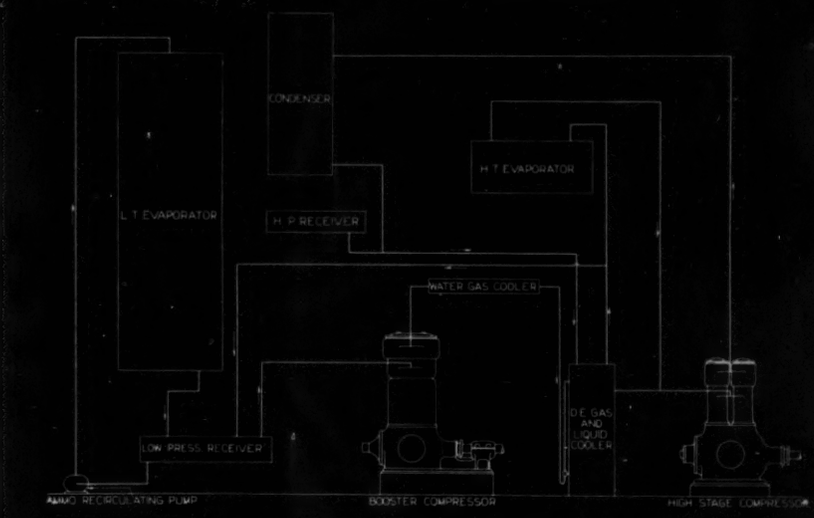
THE Eagle-Picher Sales Company has opened a completely equipped insulation divisional headquarters in the Temple Bar Building, Main and Court Streets, Cincinnati, Ohio, and announces the following personnel: M. J. Washburn, division manager, G. V. Blatz, contract department manager, G. P. Diers, staff engineer, and Albert Loring, consulting engineer.

STRATFORD Engineering Corporation announces opening of offices at 1414 Dierks Building, Kansas City, Missouri. The concern will specialize in the design and construction of the Stratford Acid Treating System. C. W. Stratford is president of the corporation and J. A. Altshuler, vice president.

THE Laclede Christy Clay Products Company, with main offices and plants in St. Louis, Missouri, announces removal of its Chicago district sales office to its new headquarters and warehouse at 4452 West Fifth Ave., Chicago. H. R. Miller, long associated with the company in a managerial capacity, both in St. Louis and Chicago, will remain as district manager.

I. E. MASKAT has accepted an appointment with Gulf Oil Corporation. He will be located at Pittsburgh.

STUDY THIS DIAGRAM



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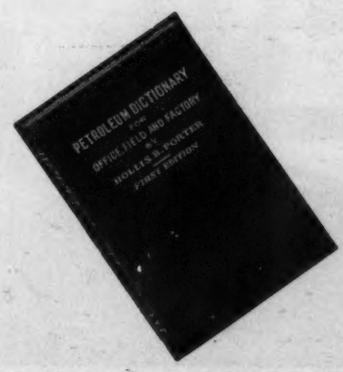

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Ideas

Arc Welding Generators Thaw Frozen Pipes

OUT of the winter season just passed comes experience indicating another use for the portable arc-welding generator. These can be used advantageously in thawing frozen pipes, particularly when the water pipes are under ground or otherwise inaccessible. The leads from the generator are connected to the pipe so as to include the frozen section in the electrical circuit, and as the voltage is adusted to provide a heavy current, the ice is melted. A user reports that 250 amperes will thaw a three quarter-inch pipe 300 feet long in from three to 10 minutes; a three-inch pipe 100 feet long will require nearly an hour with a current of about 500 amperes. Voltages vary widely, usually between 10 and 50 volts, depending upon the resistance of the pipe. Because of their special electrical characteristics, arc welding generators are capable of delivering heavy currents at low voltages.

Mixing Valve Adjustment

OFTEN engineers and operators of compressor stations with engines having the fuel mixing valve adjustment placed above the intake valve, find themselves in difficulty because a previous operator changed the mixture and failed to tell the relieving operator what he had done. To eliminate such difficulties, D. H. Toler, compressor station superintendent, Industrial Fuel Supply Company, Los Angeles, conceived the idea of calibrating each mixing valve to secure best results from a given amount of fuel and air, and to make a permanent record of the results of his study.

Each mixing valve is marked by the manufacturer by horizontal lines around the adjusting wheel stem, placed to correspond to the threads cut on the valve stem. The horizontal lines are numbered 10, 20, 30 and so on, from top to bottom. These reference numbers are not stamped on the stem because there is always one or more of the threads showing when the engine is in operation. A reference point was stamped on the valve bonnet, opposite the lock screw handle in the form of an arrow with the point toward the valve.

Ten vertical lines were then made on the valve stem, spaced equally around the circumference, with reference figures stamped on them from 1 to 10. The adjusting wheel stem is threaded with eight threads per inch. The horizontal lines were placed an eighth-inch apart, so that one complete revolution of the hand wheel moves the mixing valve an eighth-inch and either exposes or conceals on horizontal reference line. Moving the wheel one tenth revolution, or one division on the vertical scale, raises or lowers the mixing valve 1/80-inch, which provides a micrometer adjustment on the mixing valve.

After all the engines were so calibrated, a chart was prepared showing the required setting on each mixing valve, which provides a permanent record and reference for the operator to use in the event the setting is changed for any reason, as in overhauling or cleaning. When an engine is replaced in service the operator refers to the chart and takes the numbers corresponding to that particular engine and sets the mixing valve adjustment to that setting which experience has shown provides the best mixture. If the engine has been overhauled, valves ground, new rings and cylinder sleeve installed, and the fuel mixture setting must be changed, then a new reference figure for the new setting is made on the chart, superseding the one previously made.

SINCE the starting of this department in February, The Refiner has received valuable comment, suggestions and contributions. Where original such items are paid for at the usual space rates. Contributions are welcome and should be accompanied, where feasible, by a photograph or drawing of such nature that others in the industry can apply such ideas to their own plants.

Maintaining Cement Floors

CEMENT floors and aisles in various refinery departments often tend to crumble under conditions where steel wheeled trucks are employed. Such floors may be transformed into a granite-like substance, taking on a polished appearance like flint, by treating them with magnesium fluosilicate. First free the surface of oil, grease, paint, etc. Then apply the liquid which is prepared by dissolving 2½ pounds of magnesium silicofluoride in one gallon of hot or cold water.

First apply the solution of one part solution and two parts water. The next application is one part solution and one part water. The third application is the straight solution as originally mixed. The chemical can be obtained from chemical supply houses. It not only hardens, water proofs and dust proofs the surface of the cement but fills the pores, thus reducing porosity. Floors and walkways treated in this manner may be enameled or painted with oil paint.

Use of Nickel In Refineries

A FEW years back few would have ventured to assert that refineries would become important to metal fabricators, manufacturers, and similar businesses from the standpoint of developing into an outlet for nickel. Yet, in the refinery, one of the important developments during 1934 was the adoption of welded nickel steel for pressure vessels used in some of the dewaxing processes. The extremely low temperatures encountered, down to 75°F. below zero, embrittled ordinary steels, but it was found that

Mixing valve adjustments on which new reference marks have been made to enable the operator to set the engine to produce the most power

nickel steels could retain their strength and toughness. From the installations made during the past year and interest shown by other companies, it appears that an important field for nickel steels has opened up. And, among other uses for nickel alloys in refineries are the nickel-aluminum-bronze condenser tubes and nickel cast iron bubble caps and other auxiliary equipment parts.

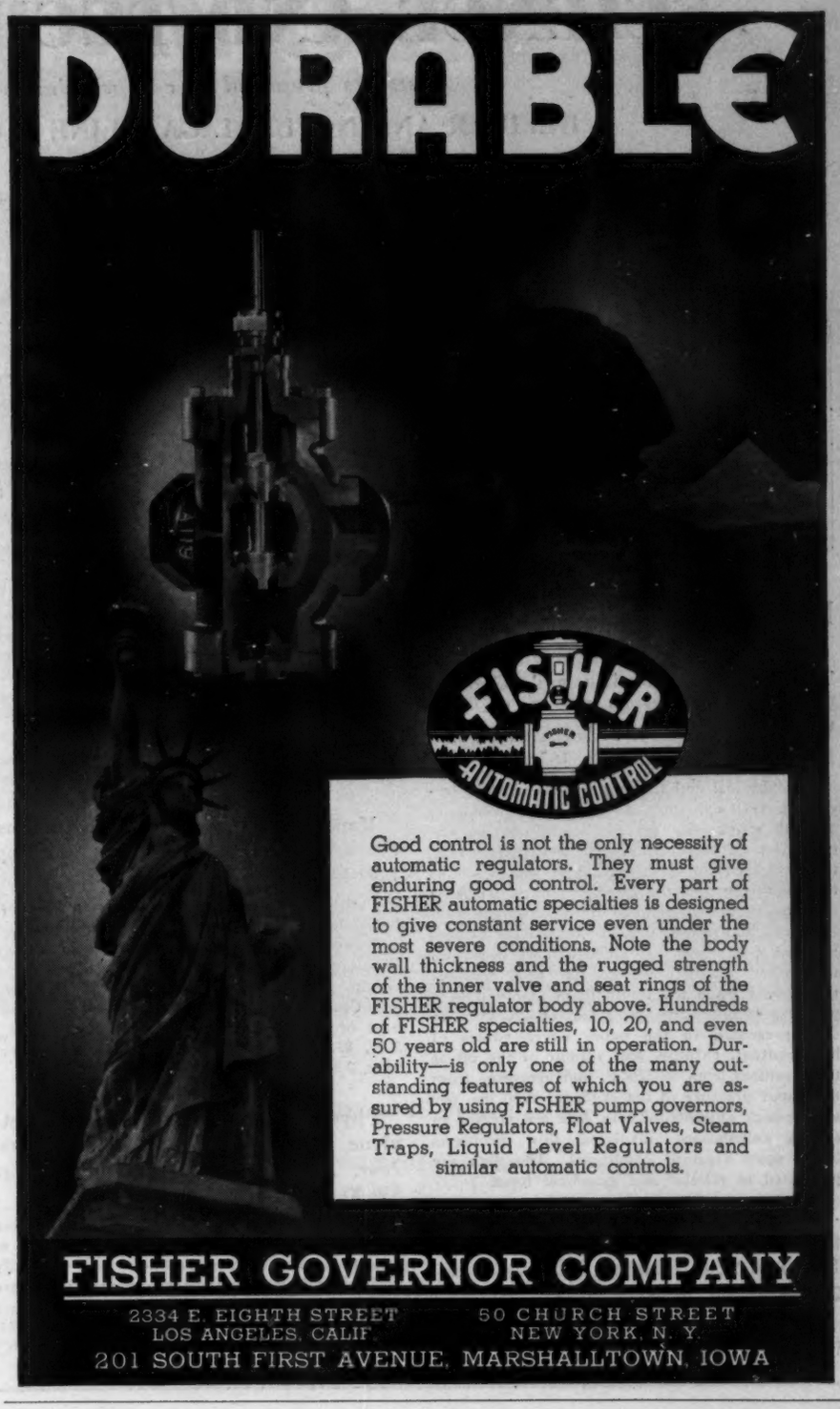
Strip Heaters Keep Control Units Warm

TEMPERATURE control instruments are delicately adjusted and their value lies in the accuracy with which they function. It was found by one manufacturer that when the grease or other lubricant in a couple of instruments regulating temperatures became too cold, the instruments became inaccurate. Since the room in which the instruments are located was one not normally heated, some method of keeping the instruments warm became necessary. Heating the room to keep two instruments warm was not economical. This difficulty was solved by attaching a 500-watt electric strip heater beneath each controller with installation being made in such manner that the heated air passed over each case. Localized heating solved the problem economically and simply.

Aldehydes From Gasoline

AFTER experimenting for three years, two chemistry professors at Mississippi State College have discovered that aldehydes—the artificial aroma producing chemicals—can be taken out of common gasoline at the low cost of about $26.00 per gallon. Perfume manufacturers in this country and abroad have shown great interest in the discovery since by the old method of producing aldehydes the cost is about $250.00 per gallon.

SQUISH—This sounds like an absurdity and looks like a misprint, but it is a new technical term, introduced, of all places, before the Institution of Mechanical Engineers in London, England, last December 14. Colloquially used in Europe for some time, it first appeared formally in a paper by J. F. Alcock on "Air Swirl in Diesel Engines" and was recommended in discussion to the notice of the British Standards Institution. What does it mean? It means simply "the radial inwards movement of the air or gases in the cylinder of an internal-combustion engine when the piston approaches the end of its upstroke and air compressed in the diminishing clearance passes toward the combustion space"—or so reports *The Power Engineer* and we borrowed it from *Power*, March, 1935.



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SCIENCE AND TECHNOLOGY

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by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical Data

Phase Equilibria in Hydrocarbon Systems. VII. Physical and Thermal Properties of a Crude Oil. B. H. SAGE, W. N. LACEY, AND J. G. SCHAAFSMA. *Ind. Eng. Chem.* **27** (1935), pp. 162-5.

The physical and thermal properties of hydrocarbon systems, such as crude oils found in natural reservoirs, are of importance in the evaluation of reservoir energy and energy relation involved in subsequent processes such as flow from the well and through pipe lines. As a preliminary to an extended study of oil-gas mixtures such as are usually found in natural reservoirs, a study was made upon a crude oil from which all dissolved gas had been removed that would leave the liquid upon standing at a pressure of one atmosphere and at 120°F. The data presented in the paper cover values of heat content, entropy, and volume of the oil at temperatures from 60-220°F. and pressures from the vapor pressure of the crude to 3000 lbs. per square inch absolute. These data are applied in sample calculations involving flow problems based upon assumed conditions. The data are presented in tabular and graphical form.

Pressure-Volume-Temperature Relations for Fractions of an Oil. R. B. DOW AND M. R. FENSKE. *Ind. Eng. Chem.* **27** (1935), pp. 165-8.

A light Mid-Continent lubricating oil was fractionated. The densities, viscosities, and indices of refraction are reported for the original oil, nine cuts, and the bottoms at atmospheric pressure and two temperatures. The pressure-volume-temperature relations have been investigated up pressure approaching apparent solidification for each of the eleven samples. The curves for the change of volume with pressure and for the variation of the thermal expansion with pressure are included for several samples.

Vapor Pressures of Hydrocarbons. SCHMITT. *Compt. Rend.* **199** (1934), pp. 1299-1301.

The liquids were degassed at least 10 times by boiling in a vacuum, freezing in liquid air, and exposing to a vacuum. The static method of vapor pressure determination was used. The results were calculated by the aid of Antoine's and Clapeyron's formulas. dp/dt and the latent heat of vaporization are, respectively, n-C_6H_{14}, 2.39, 85.1; methylcyclopentane 2.33, 86.2; benzene 2.37, 99.1; toluene 2.16, 90.5.

Physical Constants of Dimethylacetylene. G. B. HEISIG AND H. M. DAVIS. *Jour. Am. Chem. Soc.* **57** (1935), pp. 339-40.

Dimethylacetylene was prepared by the action of methyl iodide on the sodium salt of methylacetylene. The product was carefully purified and vapor pressure measurements were made at 5°C. intervals over the temperature range —31.2 to 23.65. The density at 0° is 0.715, at 25°C. 0.688. The refractive index at 25°C. is 1.3893. The lowest temperature at which the product would remain liquid was —32.8°C.

Spontaneous Ignition of Petroleum Fractions. P. J. WIEZEVICH, J. M. WHITELEY, AND L. B. TURNER. *Ind. Eng. Chem.* **27** (1935), pp. 152-5.

The spontaneous ignition temperatures of various fractions from different crude oils were determined. When spontaneous ignition temperature is plotted against boiling point, a minimum value is found in the kerosene—fuel oil range and a rapid rise takes place above 700°F. boiling point, indicating that there is a sharp change in the structure of petroleum oils above 700°F. For the same boiling points fractions from Pennsylvania and Colombian crudes show similar spontaneous ignition temperatures. Experiments were made with heated open plates and with closed bombs heated with oxygen under pressure. Oxygen proved to be exceedingly dangerous in many instances, leading to detonations as wells as to the burning of the metal. The presence of nitrogen, steam, and similar diluents greatly reduces the explosion hazard. The authors believe that soptaneous ignition temperature is a relatively simple method for indicating the structure of hydrocarbons. For the same number of carbon atoms in the molecule, the spontaneous ignition temperature decreases in the order: aromatics, alkylated aromatics, naphthenes, alkylated, naphthenes straight-chain paraffins, branched-chain paraffins, and unsaturated aliphatics.

Relation Between Boiling Points of Hydrocarbons and Their Structure. R. L. WAKEMAN. *Rec. Trav. Chim.* **53** (1934), p. 832.

The author reviews previous work on the relationship between the boiling points of hydrocarbons and their structure, and in general between the values of physical constants and the constitution of consecutive members of homologous series. Young's empirical formula for the calculation of boiling point in homologous series holds approximately for paraffins, olefines, diolefines, and acetylenes. In the lower range of molecular weight smooth parallel curves are obtained in plotting boiling point against number of carbon atoms. The boiling points of the C_2 to C_9 members are in close relationship with the boiling points of the normal paraffines having the same number of carbon atoms. In general, a fixed change in value of physical constants will be found in going from a normal paraffin to an isomeride or homologue.

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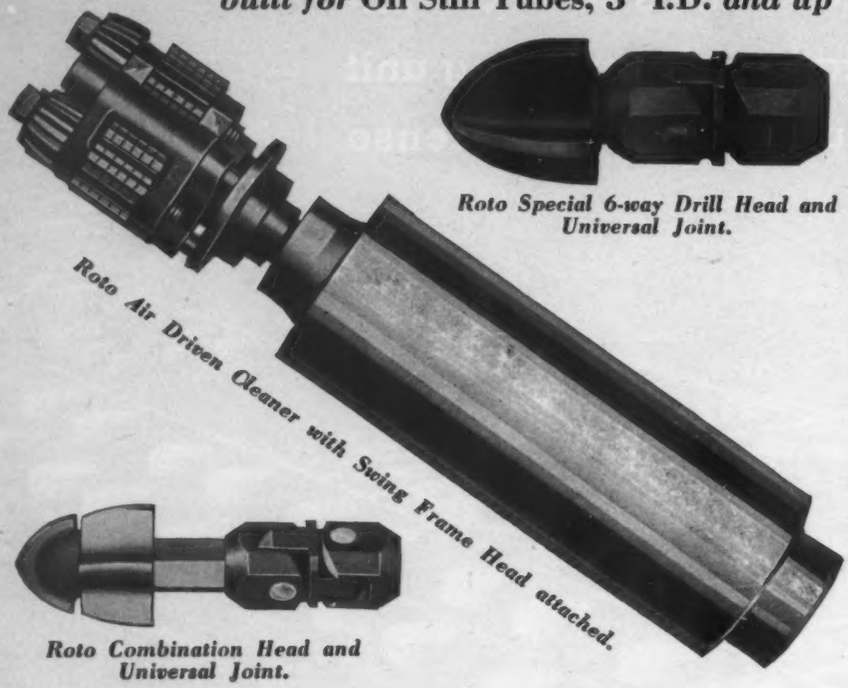

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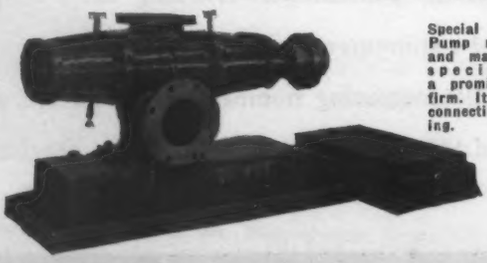

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The boiling point differences are nearly additive when the hydrocarbon has at least one SH, group between the side-chain and the multiple bond. Examples are given illustrating the calculation of boiling point of an unsaturated, straight-chain compound from a given acyclic hydrocarbon. Double bonds in the conjugated position have an abnormal effect.

Effect of Molecular Structure on the Variation of Viscosity Between the Melting and Boiling Points. MARY D. WALLER. *Phil. Mag.* **18** (1934), pp. 579-94.

The ratio of the melting point to the viscosity (r) at the boiling point is less than 4 for liquids whose molecules are spherical or highly symmetrical. For molecules of long chain structure, the value of r is higher. Fused salts also have higher values of 4 than homopolar diatomic molecules. For the substituted benzenes, the value of r increases with the Kerr constant and the dipole moment and with decreasing symmetry. Paraffins containing an odd number of carbon atoms have higher values of r than those with an even number of carbon atoms. It is suggested that the periodic variation of r as the number of carbon atoms increases in cycles of 6 in both the paraffin and alcohol series is evidence of the flexibility of the hydrocarbon straight chain.

Chemical Composition and Reactions

Analyses of Crude Oils from Some Fields of Southern Louisiana. A. J. KRAEMER AND E. L. GARTON. *U. S. Bureau of Mines Report of Investigations 3253*, NOV., 1934.

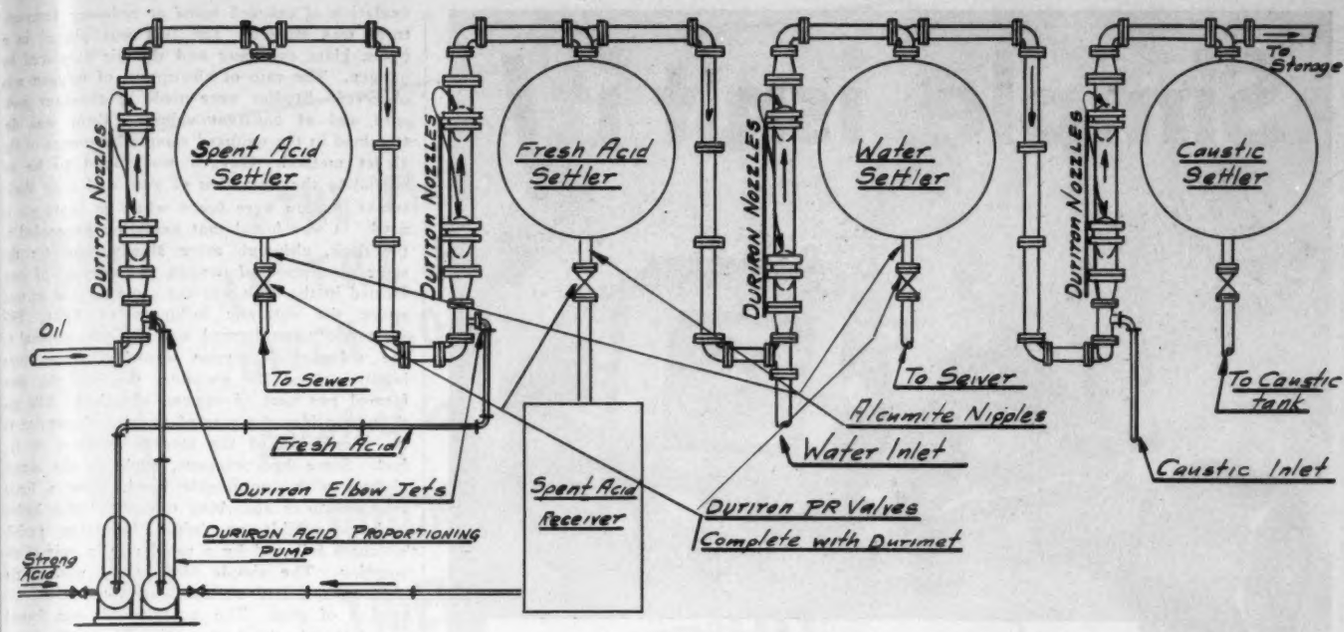
The total production for the fourteen fields has amounted to more than seventy-three million barrels. The Welsh and Jennings fields were discovered in 1901 and 1902 respectively. The Jennings had produced forty-six million barrels by the end of 1932. The Lockport field was discovered in 1924 and has since produced eleven million barrels. The oils from Lake Pelto, Lockport, Port Barre and Welsh of the Southern Louisiana or Louisiana Gulf Coast fields are of naphthene-base in which there is no wax. The oils from Gueydan, Sulfur, Sweet Lake, White Castle, and parts of the Lake Barre, Lockport, Sorrento, and Sulfur fields are naphthene-intermediate base. The crudes from the Darrow, Iowa, Leesville, Jennings, and parts of Lake Barre, Lockport, Port Barre, and Sorrento are of intermediate base and contain wax. The greater the depth of the wells, the larger the percentage of lighter fraction and the greater the trend away from naphthene-base properties to those of intermediate-base oil properties.

The Preparation and Physical Properties of Aliphatic Acetylenes. F. R. MOREHOUSE AND O. MAASS. *Can. J. Research* **11** (1934), pp. 637-43.

The authors prepared the lower members of the acetylene series, that is, methyl-, ethyl-, dimethyl- and propyl-acetylenes. The methods used are described. The various physical properties of these hydrocarbons were measured and a comparison of these properties with those of the paraffins and olefines made. The difference in properties was attributed to the polarity of the acetylene group. Numerous tables and charts are included in the paper.

Physico-chemical Researches on the Oxidation of Cracked Spirit. E. VELLINGER AND G. RADULESCO. *Ann. des Comb. Liq.* **9** (1934), pp. 901-924.

The use of ultra-violet light to catalyze the



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4"	75	6½
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10"	500	8
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oxidation of cracked spirit at ordinary temperatures was studied. The fuel was placed in a pyrex glass container and the air displaced by oxygen. The rate of absorption of oxygen was observed. Studies were made at constant pressure and at constant volume. Gum was determined in the oxidized sample by means of the air-jet method. Oxygen was found to be essential to the formation of gum and only slight traces of gum were found when an inert gas is used. It was found that oxidation proceeded in the dark, although more slowly, and for the same absorption of oxygen the amount of gum formed in the dark was the same as that formed under the catalytic influence of light. The amount of gum formed was not proportional to the volume of oxygen absorbed. The more highly refined the gasoline, the less the gum formed per unit of oxygen absorbed. The authors consider the rate of oxygen absorption to be a criterion of the storage stability of the fuel. Some hydrocarbons, such as the simple olefines with one double bond, show a linear relationship in absorbing oxygen. Other hydrocarbons exhibit an initial induction period, which is followed by a rapid rise in rate of absorption. The simple olefines, as well as the more complicated olefines, contribute to the formation of gum. The quantity of gum formed per unit volume of oxygen is larger the higher the molecular weight of the gum-forming components. Anti-oxidants prolong the induction period. The efficiency of inhibitors can be investigated by the photolytic method. Potassium dichromate in acid solution was the most satisfactory reagent studied for the removal of the readily oxidizable components of cracked gasoline, which components are those that give rise to peroxides and which accelerate gum formation.

The Explosion and Fire Hazards of Hydrocarbon-Carbon Tetrachloride Mixtures. G. W. JONES AND R. E. KENNEDY. *U. S. Bur. Mines Information Circular No.* 6805. Nov. 1934.

Tests of the flammability of mixtures of hydrocarbons and carbon tetrachloride vapors with air were made in glass explosion tubes, 16 to 20 inches long and 1 to 2 inches i.d. The tubes were sealed at one end and fitted with a cork at the other. One or two drops of the mixture to be tested were introduced into the tube, the cork was put in place, the liquid vaporized and mixed with air by shaking for 1 to 2 minutes. In a darkened room the tube was held erect, opened, and the flame of an alcohol lamp passed across the mouth. If the flame passed through the length of the tube, the mixture was flammable. The upper and lower inflammation limits for a 50-50 mixture of hexane and carbon tetrachloride, for example, were 9 and 25 drops in a tube of 475 cc. capacity. Data are given for pentane, hexane, heptane, octane, a solvent naphtha, and a motor gasoline.

Products: Properties and Utilization

Flow Resistance in Curved Rough Pipes. O. FRITSCHE AND H. LICHTER. *Forsch. Gebiete Ingenieurw.* 4B (1933), pp. 307-14.

The pressure drop in the flow of water and oil air in rough straight and curved pipes was determined. For straight pipes the coefficient of resistance $\lambda R = 0.01113 + 0.9170\ Re^{-0.41}$ between Re = 3000 and 300,000, where Re depends upon tube diameters. A table is given that shows the friction factors for curved pipe with bends from 45° to 180°.

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ous Petroleum Still. A. H. GODLIFFE. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 53-74.

The author states that the object of his work was, first, to indicate the theory and practice to be used in testing distilling equipment, and second, to secure results from which data could be determined that would be of use in plant design. The paper is divided into three parts. The first covers a description of a plant designed to produce naphthas with close boiling ranges from the lighter fractions of a variety of tops from crudes. A flow diagram of the plant is given. Logs of the run and heat balances are presented. Calculations are made covering the performance of various items of the plant equipment.

Color Stabilization of Gasoline by Amines. L. V. SORG. *Ind Eng. Chem.* **27** (1935), pp. 156-160.

The author reviews refining methods that have been used to secure initial color and color stability of gasoline. He also reviews the subject of color stabilization by means of chemical compounds. The normal aliphatic amines up to and including the amyl amines were studied experimentally in regard to their color stabilizing properties. Although the amino group is probably responsible for the color stabilizing action, the effectiveness of this group is modified by the length and number of alkyl groups attached to it. The amyl amines proved to be the most effective of the various amines studied, and of them the primary and secondary were most effective. No worthwhile gain in color stability is had by using over 0.003% by weight of a given amine. The characteristic stability of the particular gasoline treated does not greatly affect the amount of amine required to secure maximum color improvement, but the magnitude of the maximum possible color improvement varies with the amount of amine. The amyl amines pass through the operation of sweetening with plumbite and sulfur with no loss in effectiveness.

Refining Lubricating Oils by Solvent Extraction. J. V. HIGHTOWER. *Chem. & Met. Eng.* **42** (1935), pp. 82-5.

The author describes the Duo-Sol solvent extraction plant of the Magnolia Petroleum Company at Beaumont. The plant runs 23 gravity residual stock from Oklahoma crude at the rate of 2000 barrels per day. Twenty-five percent of the charging stock is extracted as naphthenic oils. The flow of materials in the plant is outlined. A table is given comparing the properties of the charging stock, raffinate, extract, and dewaxed and filtered raffinate.

The Selective Solvent Action of Water-Free Phenol and Cresol for Mineral Oil and Similar Hydrocarbon Mixtures. H. SUIDA AND H. POLL. *Petroleum Z.* **30**, No. 25 (1934), pp. 4-7.

A Roumanian distillate was extracted with anhydrous nitrobenzene, phenol and cresol. The yields of refined oil were, respectively, 23, 55 and 31%. The raffinate from the cresol extraction was the best product as regards viscosity index, carbon content and thermal stability. A series of distillates ranging from spindle oil to cylinder oil was studied with reference to the selective solvent action of cresol. Various distillates from naphthene, paraffin and mixed-base crude, and also synthetic oils, were examined.

Effect of Continued Heating on Asphalts. A. W. SIKES AND C. H. COREY. *Ind. Eng. Chem.* **27** (1935), pp. 192-5.

The authors note that a comprehensive review of the literature revealed few data concerning the extent of the progressive changes in the properties of asphalts that are brought about by continued heating at definite temperatures. Continued heating at the temperature and under the conditions of the experiments reported, appreciably affects many properties of certain asphalts and asphaltic materials. Viscosity and penetration change most rapidly for the first few days or weeks of the heating period, whereas flash points are least affected even after many weeks. The softening point changes regularly but markedly throughout the period of test. Acidity decreases but finally reaches a constant figure after an initial increase. The data are presented in graphical form. The authors state that they realize that the results reported may not be duplicated with different materials or under different conditions of heating.

The Determination of the Suitability of Bituminous Coatings for Underground Pipes. G. O. THOMAS. *J. Inst Engrs. Australia* **6** (1934), pp. 337-46.

The general subject of the protection of underground pipes is discussed. Destructive influences are electrolysis, the effect of solvents contained in sewage, and attacks by bacteria and termites. Results are given of tests in which a series of coatings of increasing thickness was examined for penetration of water by measuring the break-down of electrical resistance. Horizontal-retort coal-tar pitch excels all of the other common bituminous materials in its resistance to water and in permanent adherence to steel. However, its mechanical properties are not so favorable. This particular tar, however, is used in standard practice in Melbourne for coating steel pipes. The pipe is treated at a temperature between 250 and 400° F. and is then wrapped with a coarse woven fabric similar to sacking, whereupon an exterior coating is given composed of a mixture of coal-tar pitch and up to 40% of 200-mesh limestone. The result is a protective coating of low penetration, high tensile strength, high melting point, and high dielectric strength.

Welding of Structures in the Chemical Industry. C. O. SANDSTROM. *Chem. & Met. Eng.* **42** (1935), pp. 94-5.

This is the last of a series of three articles discussing the application of welding in the chemical industry. The author notes that evolution in the arts is frequently hampered by vestiges of former practices. Specifically, the art of fusion welding when applied to structural steel must accept the shapes and, to a considerable extent, the assemblages of the old riveting practice. Fastenings are first discussed and both wrong and proper types illustrated. Present forms of columns were designed for convenience in riveting shelves and lugs for the support of beams. In present I or H sections the radius of gyration about one axis is frequently several times that about the other. This section is advantageous when the load is eccentric about the principal axis, but otherwise is a waste of material. Circular columns have a constant radius of gyration and so have the ideal form for concentric loading, but until the use of fusion welding, the difficulty of attaching adequate beam connections precluded their general use. The use of cheap tubular members for columns will come with the application of welding to building construction. Fusion welding is especially adapted to the construction of roof trusses, towers and frames. The members can be welded at the end so as to develop full strength, a thing which is quite impossible with riveted members. Tubular members are ideally adapted to welding construction.

Manufacture:
Processes and Plant

Butane as an Automotive Fuel. D. P. BARNARD. *J. S. A. E.*, **35** (1934), pp. 399-401.

The distribution of butane for use as an automotive fuel presents some difficulty because the product must be handled and stored under pressure. The anti-knock rating is high, but the specific gravity is so low that the volumetric fuel economy is also low. Fire risk is considerably greater than with gasoline. The author reaches the conclusion that butane cannot be economically adapted to use in small automotive units, but that it should be suitable for use in an engine of 800-1000 h.p. for railway service. Figures are given showing the quantity of butane produced. This would not be sufficient for more than 10% of the registered commercial vehicles in the United States in 1935.

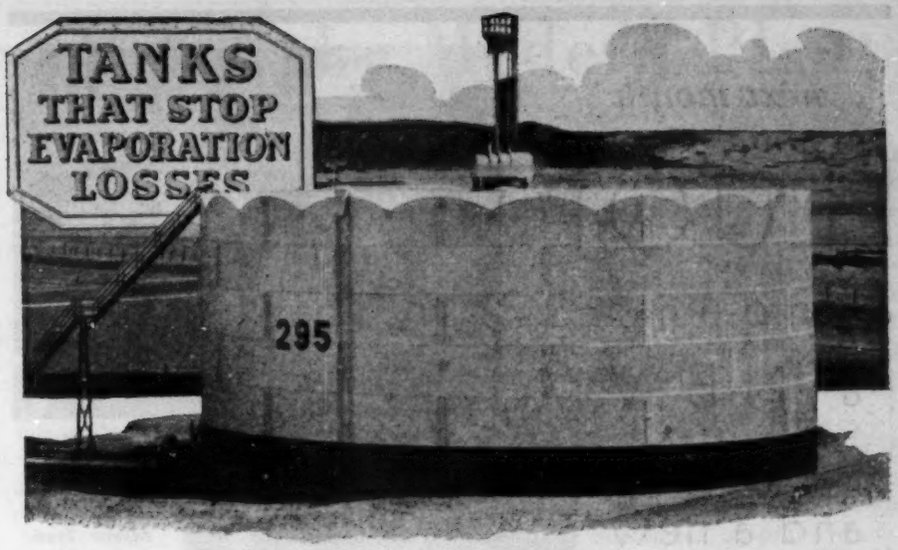
Gasoline, Aviation, Fighting Grade, Anti-Knock (92 Octane Number Nominal). Oct. 27, 1933. Specification No. Y-3557-G. Material Division, Air Corps, Wright Field, Dayton, Ohio.

The specifications permit the addition of benzol or of tetraethyl lead. It shall cause no gray or black corrosion in the copper dish. Gum, by the accelerated aging test at 100°C. with oxygen at 100 lbs. pressure for four hours, shall not exceed 10 milligrams per 100 cubic centimeters. The weight of metallic lead is deductible. Sulfur shall not exceed 0.10. Distillation range —167°F. at not less than 10%, 212°F. at not less than 50%, 275°F. at not less than 90%. The sum of the temperatures at the temperatures at the 10, 50, and 90% points shall not be less than 564°F. The Reid vapor pressure at 100°F. shall not exceed 7 lbs. The freezing point as indicated by initial formation of solid shall not be higher than —76°F. The octane number shall be determined by the Air Corps specifications, using a C. F. R. engine. The nominal octane number is 92.

Determination of the Aromatic Content in Cracked Gasolines. J. C. VLUGTER. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 36-9.

In the absence of olefins, aromatic hydrocarbons in cracked products can be determined by means of determining the volume loss upon treatment with concentrated sulfuric acid. It has been proposed to eliminate olefins by the use of sulfuric acid at 80% to 95% strength, but it has been proved that an acid of proper concentration to completely eliminate olefins also attacks the aromatics. However, the olefins can be eliminated as the cause of trouble by selectively hydrogenating them at 300° C. under high hydrogen pressure and in the presence of a specially prepared molybdenum catalyst. In extremely rare cases a disturbing polymerization occurs during the course of this hydrogenation, owing to the presence of very active olefins and diolefins. This neccessitates a preliminary hydrogenation at a lower temperature with a nickel catalyst. In a typical instance a vapor-phase cracked gasoline had a bromine value of 179.3. After hydrogenation with nickel catalyst at 150° C. the bromine value was 115.9. After the second hydrogenation with molybdenum catalyst at 300° C. the bromine value was 0.4. The final reaction product treated with 98% sulfuric acid showed 7.6% by volume of aromatic hydrocarbons. It was proved that the aromatics were not hydrogenated in the preliminary treatment to remove olefins.

Causes of Detonation in Petrol and Diesel Engines. G. D. BOERLAGE AND W.



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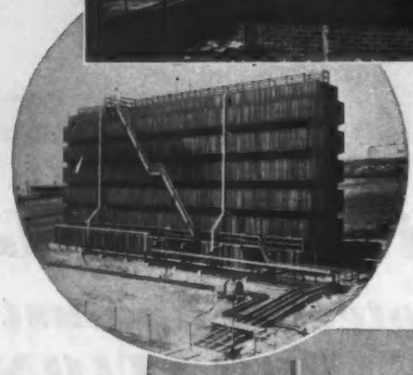

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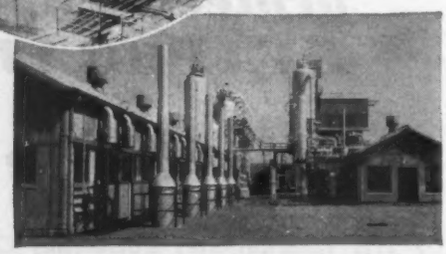

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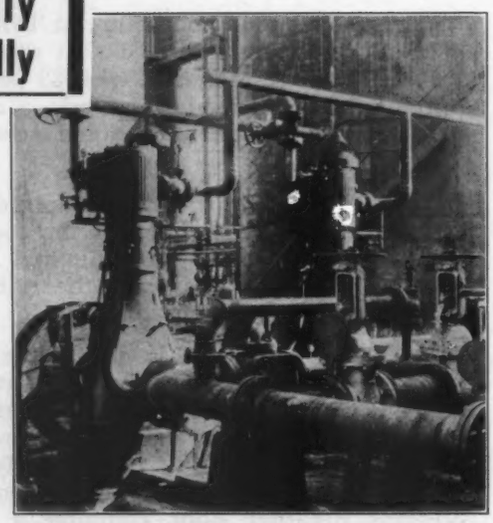

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934 Railroad Avenue, Troy, Pa.

TROY-ENGBERG
HORIZONTAL AND VERTICAL STEAM ENGINES • A.C. & D.C. GENERATING SETS

J. D. VAN DYCK. *Jour. Inst. Pet. Tech.* 21 (1935), pp. 40-52.

The authors show that the combustion phenomena of Diesel and gasoline engines are similar in many respects. Self-ignition of the charge in both engines depends upon the interaction of activated oxygen and activated hydrocarbon molecules. Detonation may occur in both types of engines and is caused by the vibration of the gases resulting from local rapid change of pressure. A knock can also be produced by mechanical vibration of the walls as a result of the high rate of change of pressure. Vibration of other engine parts may also produce a knock. Rough or bumpy running is caused by vibration of heavy engine parts, such as the crank-shaft.

Relation Between Degree of Refining of Motor Oils and Their Behavior in the Engine. H. RAMSER AND H. KREKELER. *Angew. Chem.* **47** (1934), pp. 765-768.

Crankcase oil was used in a 15-h.p., 4-cylinder, stationary test engine. The oil was heated to 110° C. by means of an electric heater, and used under prescribed conditions to accelerate the aging of the oil. After a period of 21 hours or 50 hours, the oil was drained. A number of oils were specially refined by treatment with sulfur dioxide, sulfur dioxide-benzol, or sulfuric acid. The degree of refining was found to have no marked influence on oil consumption or on carbon formation. Also the physical properties, acid and saponification numbers of the used oils showed no characteristic difference. Sludge formation was found to be governed by the degree of refining and in this regard the solvent-refined oils were superior to the acid-refined oils and to commercial motor oils of good quality.

Investigation of Lubricating Value. V. VIEWEG. *Ol und Kohle,* **2** (11) (1934), pp. 494-501.

The article is a report of the session of the German Institution for the Investigation of Mineral Oils. Experimental work was conducted at the Technical Institutes of Dresden, Karlsruhe, and Munich. Both chemical and physical research show that the molecular forces between the limiting surfaces and the lubricating media are dependent upon the lubricating value of the oils. A method for the quantitative determination of lubricating value is being considered.

The Utilization of Paraffin Wax and Petroleum Ceresin. P. G. HIGGS. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 1-24.

The author briefly reviews the history of the production of paraffin waxes, starting with the discovery of Reichenbach in 1830. In the middle 50's a small but regular production of paraffin wax was obtained from Burmese petroleum. The applications of paraffin wax, and the particular types of waxes best adapted to each of these, are then discussed. Among these are the use of paraffin wax as an illuminant, as a water-proofing agent or air-proofing agent for paper, fabric, wood, and leather, as an agent for the impregnation of various articles, as a sealing, filling and insulating material for numerous uses in the electrical industries, and as a material for use in preparing solutions or emulsions that permit the indirect application of the wax for a great variety of purposes. The author is of the opinion that the use of paraffin wax emulsion merits wider study and use. Typical formulas for wax emulsions are given. Petroleum ceresins are characterized by fairly high melting points and by microcrystalline structure. These materials have proved to be a valuable addition to the usual line of petroleum waxes. They have been made with melting points as high as 93° C., and these high melting point types have been used as substitutes for the natural high melting waxes such as carnauba, insect wax and beeswax.

New Equipment for the Modern Plant

Monobloc Centrifugal Pumps

WORTHINGTON PUMP & MACHINERY CORPORATION

Worthington Pump & Machinery Corporation, Harrison, N. J., has added two larger units to its monobloc centrifugal pump group. The new pumps, of sizes three and four inches, are essentially similar in design to the original smaller (1 to 2½ inches) units of the line, and considerably extend the range and capacities of the group.

This pump, besides being rigidly mounted on the motor frame, is supported by a foot resting on the base. The pump impeller is mounted directly on the motor shaft and both pump and motor are bolted to one rigid base, thus relieving the pump from possible pipe strain. Additional improvements are in impeller design, renewable wearing rings, and balance rings that eliminate end-thrust and put the stuffing box under suction pressure only, thus increasing the efficiency and active life of the unit.

A choice of a variety of material combinations permits selection for a widely diverse character of services. In the matter of fittings, these pumps can be furnished in standard bronze, all bronze, or all iron. Electric characteristics may be any standard or any specials. Motor construction may be standard (splash-proof) or special (explosion-resisting etc.). Mounting can be either horizontal or vertical.

Mercury Vapor Lamp

GENERAL ELECTRIC VAPOR LAMP COMPANY

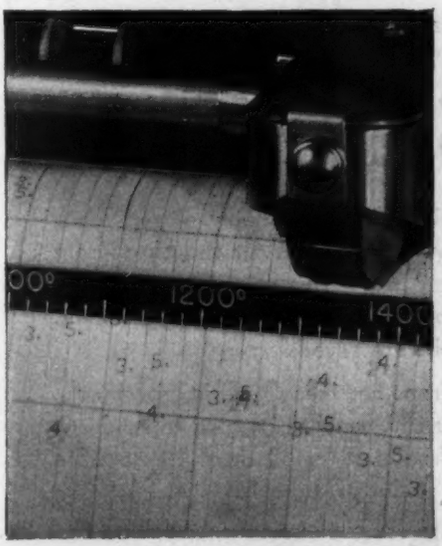
General Electric Vapor Lamp Company of Hoboken, New Jersey, has perfected a high intensity mercury vapor lamp which is particularly suitable for high bay lighting. It is a new approach to an industrial white light which is restful to the eye, which enables quick visual response even to details unknown under other commercial lighting. It promotes of continued use of the eyes without fatigue. It is a particularly efficient lamp in that it produces 14,000 lumens at a consumption of 400 watts or approximately 35 lumens per watt. It is made with a Mogul screw base for vertical mounting. The lamp has an over-all length of 13 inches and is designed for operation on 110 volt and 220 volt, 60 cycle circuits. It has an average life of 1500 hours.

From a technical standpoint the high intensity light is not white. It is a combination of blue light and yellow-green which produces a whiter sensation to the observer. Due to the practical absence of red rays in the light, true color values are not always rendered when red materials are involved, but this has no immediate bearing in the industrial field where fine color discrimination is rarely called for. The make-up of energy which gives the high intensity its color quality is interesting in that the major portion of energy is produced in the center of the visible spectrum (yellow-green area) to which eyes respond most efficiently. The balance of the visible energy produced by this lamp is at the blue end, which while it has little visual value does reduce the glare factor and does produce the sensation of a whiter light.

Multiple-Point Recorder Marking System

LEEDS & NORTHRUP COMPANY

Reading of multiple-point instrument records is greatly simplified by a new system of "numerals in colors" introduced by Leeds & Northrup Company, Philadelphia. This marking system can be specified on Micromax strip-chart recorders for two, three, four or six points. With each of the thermocouples, resistance thermometer bulbs or other primary elements identified



Multiple-Point Recorder

on the chart by a numeral, and each numeral distinguished from the others by being printed in a contrasting color, reading of records is made easy, errors are avoided and time is saved. Colors used for printing the numerals are: black, green, red, violet, yellow and blue.

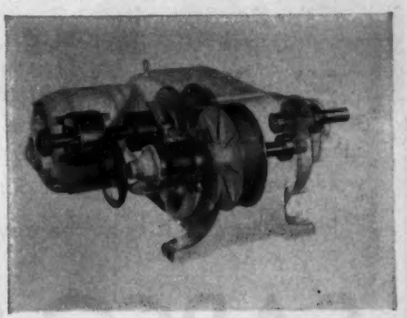
The print-wheel on these Micromax Multiple-Point Recorders has a separate inking pad for each point to be recorded.

A circular giving further details and showing a reproduction of an actual chart in all six colors will be sent on request. Address the above company and ask for Circular No. 314-I.

Electric Motor

U. S. ELECTRIC MFG. COMPANY

U. S. Electrical Manufacturing Company has announced an improved development in variable speed for use in the oil industry. A new lever arm construction has been developed for the larger horsepower ratings of the company's "Varidrive" motor to make one unit of the constant speed motor, a variable speed device, and the gear case. The improved design saves space and eliminates mounting bases and transmissions, such as couplings, fans, and belts between component parts.



Varidrive Speed Reducer

The speed change is obtained by the micro-speed control which varies the effective driving diameter of the "Varidiscs." These discs expand and contract for higher and lower speeds, transmitting power through the "Varibelt" to the take-off shaft.

A.S.T.M. Daylight Lamp

C. J. TAGLIABUE MANUFACTURING COMPANY

C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y., offers a new daylight lamp for color determinations which gives an illumination more closely approximating daylight conditions for color tests. This new, adjustable type, TAG-Macbeth Daylight Lamp is suitable for use with the TAG Saybolt Chromometer, A.S.T.M. Serial D155-34T and D218-34T; also the TAG Robinson Colorimeter.

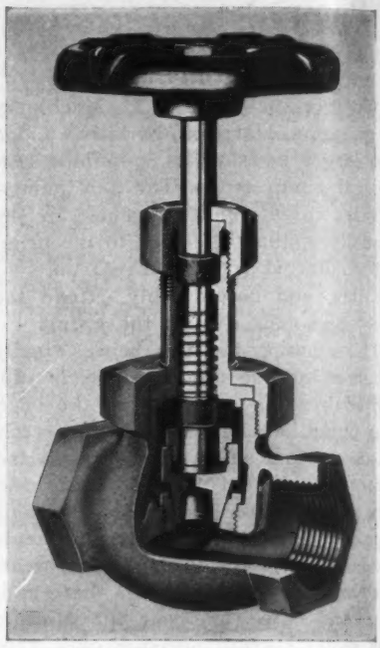
The company states that its Union

Colorimeters are now equipped with this new daylight lamp, attached by means of an adjustable bracket. Where Union Colorimeters are now in use, the old lamp should be removed and a new lamp procured in order to meet standard specifications. In addition, the specifications require the insertion, in the Union Colorimeter, of a piece of new flashed opal diffusion glass which TAG can supply to bring the instrument up to date.

Plug Type Valve

FAIRBANKS COMPANY

Fairbanks Company, 393-99 Lafayette street, New York, recently brought out a plug valve designed for service where there is excessive wire drawing or destructive action of any kind on the valve seat or disk, such as when used for drip, drain, throttling, etc. The long seating surface between the plug and the seat is said to insure added life. When these surfaces become scored or cut they can be readily reground or renewed if necessary. Due to the angle of the plug and seat ring sealing surfaces, the stream flow is uniformly distributed when passing between these components. Manufacturers claim the force of the stream cannot be concentrated on any part of the plug or seat and produce erosion or wire drawing. The seat ring is screwed into the diaphragm, providing easy renewal. Both seat and disk are made of special nickel alloy of high brinnel hardness and can be reground indefinitely without removing the valve from the line.



Fairbanks plug type valve

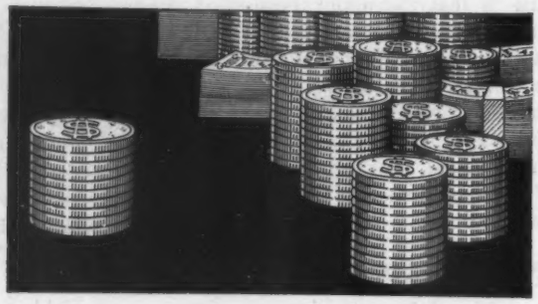
Oil-Blast Breakers

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, announces a line of new oil-blast breakers for panel mounting, designated as Type FK-43. The new type requires 35 percent less floor space because of the oil-blast principle of interruption, which also increases the reliability of operation. Maintenance is reduced materially; silver-to-silver current-carrying contacts prevent cumulative overheating and a new type of solid butt interrupting contacts will stand thousands of operations. Any mounting—such as panels, cubicles, in cells, or on pipe work—can be used; and the breakers can be operated either manually or electrically. It is universally applicable.

The new FK-43 breakers are rated: 600 amperes, 15,000 volts; 1200 amperes, 7500 volts; with an interrupting rating of 50,000 kv-a. at the rated voltage.

Among the features of the new breaker are that all three poles are enclosed in one frame and tank, saving time during inspection and giving a compact construc-



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Investment Saved $937.50

Have you ever figured the loss by radiation from centralized trapping compared with individual traps?

Suppose you had five units connected to one float or bucket trap with 50 feet of 3" bare piping. You would then waste $937.50 worth of coal (at $5.00 a ton) in 10 years—for every foot of that piping would waste 750 lbs. of coal per year.

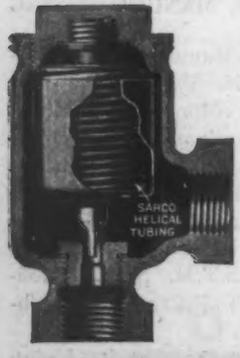
However, this is only one advantage of

SARCO Steam Traps

When each coil or jacket is equipped with a separate trap, each unit in the plant is independent of every other unit. Air and condensate are removed rapidly and continuously, regardless of varying pressures in the return lines. There can be no air bound or water logged coils. Production is increased and heat units are saved.

The 1935 series of Sarco No. 9 Traps has many vital improvements. Let us tell you about them, or better still, we shall be glad to send one or more traps on free trial for 30 days. Please state size and maximum steam pressure.

Our latest catalog No. S-95 will interest you.



SARCO CO., Inc.

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Branches in Principal Cities

Sarco Canada Limited

Federal Bldg., Toronto, Ont., Canada

tion, and that the frame and tank are completely fabricated from steel plate, with all joints welded. The breaker mechanism is of the internal type, giving freedom from pumping and better protection to connected apparatus. Bushings are of Herkolite rather than porcelain. Only eight, instead of the usual 13½, gallons of oil are required.

Solenoid-operated breakers are equipped with the trip-free Type MS-5 mechanism, insuring positive tripping when closing on fault currents; and rectifiers and current-trip coils are available for a-c. control. Manually operated breakers are provided with the trip-free HC-2 lever; and remote operation with the operating lever mounted on a panel can be arranged readily.

Compressors

WORTHINGTON PUMP & MACHINERY CORPORATION

Worthington Pump & Machinery Corporation, Harrison, New Jersey, is offering a steam booster compressor which was designed to take steam from an existing boiler system, raise its pressure beyond the capability of the boiler itself and distribute it to points of demand. This booster has been developed to take care of situations where, as often happens, a supply of steam of higher pressure than can be obtained from the available steam sources is required.

Chilling Machine

CARBONDALE MACHINE CORP.

Carbondale Machine Corporation, Harrison, N. J., announces improvements in chilling machines for use in the petroleum refineries.

One of the improvements is the patented Flexible Ribbon Conveyor, shown in Figure 1. This conveyor is carried on self-clearing bearings and rotated within the inside pipes of the double pipe apparatus, Figure 2. The cooling medium, brine or evaporating ammonia, flows through the annular space between the concentric pipes. The outer pipe is eight inches and the inner pipe six inches in diameter. During the cooling process the refrigerated solution deposits certain constituents which tend to adhere to the surface of the inner tube, but are prevented from adhering by the constant rotation of the flexible ribbon conveyor. The ribbon cleans the inner surface and at the same time agitates, increasing the transfer of heat. The design features are shown in Figure 1.

The driving mechanism of the chilling machine has also been rearranged and improved, as shown in Figure 2. The shafts carrying the ribbon conveyors project through deep stuffing boxes in the end fittings, and are rotated by means of sprockets and heavy link belt chain. After years of experience with all types of drives, this design has been chosen because of the

FIGURE 1

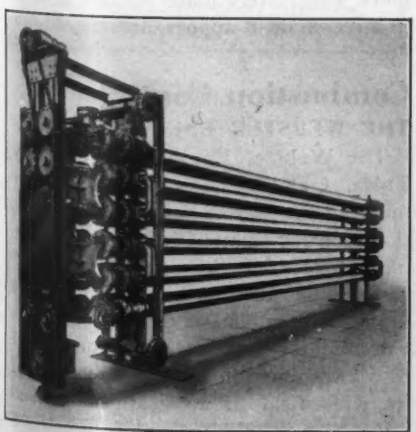


FIGURE 2

GARLOCK 7021

Dependable Gaskets

GARLOCK 7021 *is constructed of long fibre asbestos scientifically blended with heat and oil resisting compounds and bonded into sheet under tremendous pressure.*

Specially developed by Garlock to withstand extreme pressures and extreme temperatures, Garlock 7021 keeps joints tight under the most severe conditions. Use this superior gasket material on your pipe lines and equipment handling gasoline, oil, gas or steam.

THE GARLOCK PACKING COMPANY
PALMYRA, N. Y.
Tulsa, Okla. Houston, Texas Los Angeles, Cal.

Garlock

well known high efficiency of the chain drive, its ruggedness, and dependability.

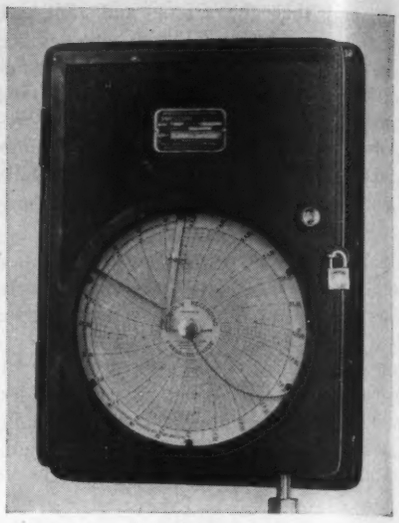
Improvements in direct expansion chillers have also been developed, for which patents have been applied.

Where the size of the refinery permits, these chilling machines make good interchangers of heat between cold and warm oils. Much refrigeration can often be saved by utilizing the low temperature of wax free oils in this apparatus. When used for this purpose, however, they are usually specially designed to meet the individual refinery conditions.

Absolute Pressure Gauge

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Conn., has developed a direct reading recording absolute pressure gauge for presssure measurement. This instrument is a recording vacuum gauge which is compensated for changes in barometric pressure and is also compensated for changes in temperature. It, therefore, reads direct in pressure absolute.



In industry, a need has developed in many processes for direct reading recording type of absolute pressure gauge which could be used by operators and practical men and read direct without confusing their minds or being delayed by any necessity for applying barometric or temperature corrections.

The recording absolute pressure gauge is equipped with two measuring elements which are coordinated through a special differential transmitting linkage of ingenious design. One measuring element is connected to the vacuum line and the other functions in connection with the compensating features of the recorder.

This instrument can be furnished for ranges as low as 25 millimeters head of mercury absolute pressure or its equivalent.

Meter Panel

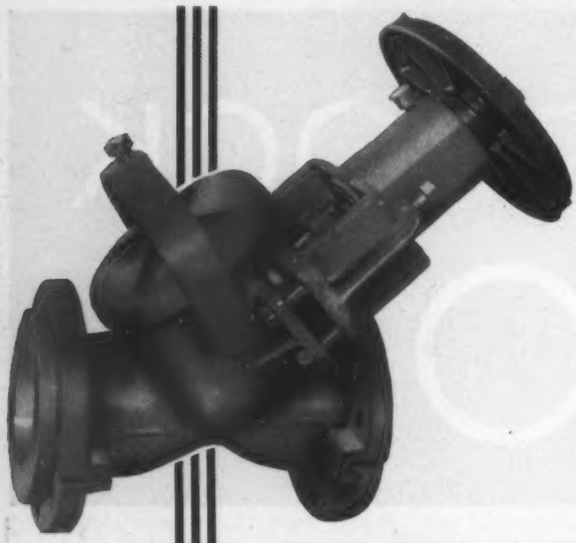
BAILEY METER COMPANY

Bailey Meter Company, Cleveland, Ohio, has announced a cabinet type steel meter panel equipped with doors to protect and conceal meter and control connections. The paneled doors are provided with a three-point locking mechanism and a substantial cylinder lock. The panels are made of one-piece sheet steel plate formed in sizes to give a neat appearance.

Combustion Control

THE WEBSTER ENGINEERING CO.

The Webster Engineering Company, Tulsa, Oklahoma, announces development of the WECO precision combustion control system, draft compensating type, which the owners claim represents an advancement in the technique of combustion practice. This development is said to be of importance to all combustion problems because of its wide field of application, its flexibility, its simplicity, and definitely established precision operation—which



ACID VALVES

Developed for the chemical industry by a company which for years has been familiar with the moving of processed liquids, LaBour Chemical Valves have amply demonstrated their stamina and the economy of their use. The increasing use of various acids in refining processes places greater and greater importance upon the selection of the handling equipment. LaBour Valves for use with acid are a safe choice.

Standard materials used in LaBour Chemical Valves are suitable for most of the acids outside the chlorine group, and practically all caustics. To meet special conditions, valves of the LaBour construction can be furnished in various alloys and combinations.

LaBour engineers will be glad to help you with your problems in controlling the flow of acid. There is no cost or obligation when you submit your problems to them.

ORIGINATORS OF THE SELF-PRIMING CENTRIFUGAL PUMP

THE LABOUR COMPANY, Inc.
407 STERLING AVENUE
ELKHART, INDIANA

continually effects economies in boiler plant operation. The Weco Precision Combustion Control (Draft Compensating Type) is entirely automatic in its operation. The manufacturers state that it is an efficient, compact powerful machine, regulating the gas-air ratio at all loads and maintaining it at a predetermined point. This results in substantial fuel saving. The control does all of its compensating outside of the furnace. The proportioning device is so designed that the velocity of the gas and air actuate the control before entering the furnace, resulting in a positive air-gas ratio regardless of furnace shape, size, or eddy current conditions. The Weco motor modulator is of sturdy design, with no open of sliding contacts, and uses the Bourdon tube as an actuating element.

The manufacturers state that due to sensitive gas-air ratio control the Weco precision combustion control makes it possible to obtain and maintain higher carbon dioxide percentages, and to maintain a constant CO_2 under any load conditions without CO within wide ranges.

Vibration is said to be eliminated. Steam pressures may be held with plus or minus one percent or the pressure can be adjusted for variation up to plus or minus seven percent. The system automatically compensates for varying draft conditions due to barometric or wind changes and automatically compensates for varying gas pressures.

PETROLEUM COKE

With a maximum of 1% Ash wanted direct from producers in quantities of approx. 300 tons. (Annual consumption 1200 tons). Offers cif Trieste with Analysis and 1 kilo as sample to

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Electrically Driven Centrifuges
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It is said that the control is simple to install and is simple to adjust, since there is only one point of adjustment. Due to the fact that there are 12 different types, flexibility is assured. The control may be operated either with electrically operated gas valves, manual operated gas valves, gas operated gas valves, electrically operated damper device, hydraulic operated damper device or manual operated damper device.

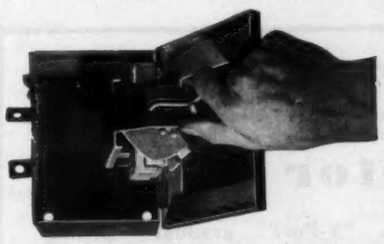
The control is applicable to all types of atmospheric gas burners using either natural induced, or forced draft. Also, where a satisfactory operating damper operating mechanism exists, either hydraulic, or electric, this control may be applied, thereby reducing cost. Burners may be cut in or out without affecting adjustment of the control.

The Webster Engineering Company has prepared a very informative, valuable and interesting technical discussion in Bulletin form, and which deals effectively with the precision combustion control system and its application to various needs.

Swing-Out Interior Switch

SQUARE D COMPANY

Square D Company, Switch and Panel Division, Detroit, is introducing



New Square D switch embodies swing-out interior.

a new line of type D 30-ampere switches with a novel swing-out interior, which is said to appreciably reduce the time and cost of wiring. A major feature is the fact that the base and operating mechanism are mounted on a metal supporting plate which is hinged to the side of the box. By pulling on the operating handle, the entire interior swings out and away from the box, leaving the box area open for unobstructed wiring and conduit connections.

With the wire and conduit in place it merely is necessary to swing the interior back into place and the connections can be made. The hinged interior is self aligning. The handle slipping into the slot at the side of the switch automatically brings the interior into place and retains it there. The interior may then be secured by a single set screw. Compact size of the interior gives plenty of room for

Speeds removal of asphalt deposits!

Four days of laborious hand chipping were formerly needed to remove an asphalt deposit from one firm's heat exchangers.

Now, OKEMCO, an Oakite product is circulated through the exchanger. A thoroughly clean job is accomplished in less than a day. No wonder the Oakite method is standard practice at this plant now.

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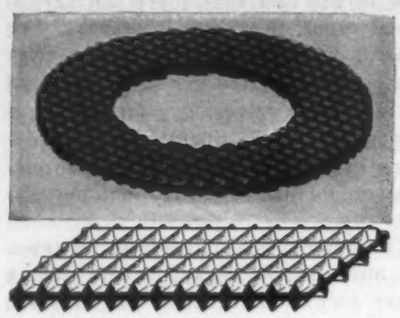
grounding bushings in all knockouts. The hinged support is elevated from the back of the box to provide ample space for laying wires behind the base without pinching the wires.

Other features of this new line of switches include knockouts to align with standard Square D fuse cabinets and socket type motors. Switches with end walls with standardized motor twist-outs are available also. Additional features include one piece combination jaw and connectors, eliminating the possibility of loose connections and backed by the porcelain base to prevent turning, and insuring perfect alignment of the switch blades.

Gaskets

GOETZE GASKET & PACKING CO.

Goetze Gasket & Packing Company, New Brunswick, New Jersey, has announced a new metallic or semi-metallic gasket to withstand extreme pressure, temperature change and vibration. The new gasket was designed to produce full tightness with only 30 percent as much contact surface as on the plain flat metal gasket. The quicker sealing effect is accomplished by providing the faces with crossed ductile and resilent raised ribs, which the manufacturer claims will set themselves into tight contact, even on imperfect flange faces. The gaskets are available in solid copper, steel, iron,



aluminum or lead, or as a metal shell with asbestos filler, and in any circular, elliptical or special shape.

Grinding Attachment

LANDIS MACHINE COMPANY

Landis Machine Company, Waynesboro, Pa., is offering a tap chaser rake grinding attachment, a fixture for use in regrinding or sharpening the chasers used in the company's Style LT and LM receding chaser callapsible taps.

The attachment is composed of three main parts, consisting of a base which is adapted for fastening to the table of most makes of tool and cutter grinding machines; the swivel bracket attached to the base; and a vise base which is clamped to the swivel bracket to hold the chaser while being ground. The swivel bracket is adjustable in a horizontal plane in relation to the base. The vise base can be rotated in the vertical plane and securely clamped at any angle as determined by graduations on top of the swivel bracket.

Gas Masks

E. D. BULLARD COMPANY

E. D. Bullard Company, San Francisco, has developed a new type of outfit to meet the flexible requirements of many users of gas masks. Known as a reel hose mask, the apparatus consists of a standard face piece and body harness, air hose mounted on a portable reel, and a portable, aluminum blower, which may be entirely removed from the carrying trunk.

The light weight of each of these units makes it possible to carry them from place to place without trouble. By carrying the blower to a point near the place of use, a minimum amount of hose is necessary. Yet in spite of the light weight and portability, the manufacturers claim this blower will develop 27.5 percent more air than the standard blower. This increased capacity is due to improvement in design and selection of materials of construction.

The blower is mounted on an oak base and set on the top of the carrying trunk. This reel hose mask is used in urban operations as well as in operations in the field. Many operators have clamped the blower to the running board of an automobile.

Welding Electrode

THE LINCOLN ELECTRIC COMPANY

The Lincoln Electric Company, Cleveland, Ohio, has announced a new hard surfacing electrode which is designed for building up straight carbon steel, low alloy or high manganese steel surfaces to resist abrasion. The new electrode, known as "Abrasoweld," will be found useful in such applications as restoring teeth, lips and bottoms of power shovels, lugs and treads of tractors, housings and impellers of centrifugal sand pumps, gear and pinion teeth, and other equipment.

The electrode provides a deposit of abrasion-resisting alloy of the self-hardening type, such a surface hardening very rapidly under conditions of impact and abrasion. Weld metal produced by this new electrode must be ground to shape, as it cannot be filed or machined. The deposit is more resistant to corrosion than high manganese steel.

CF **FULTON**

"V-Port" Motor Valves

THE "V-Port" gradual opening valve here shown is most commonly used with flow controllers, temperature controllers, and instrument-type auxiliary controlled pressure regulators in oil refinery and various industrial applications. It can be furnished for either direct action, in which diaphragm pressure causes the valve to close, or indirect action, in which diaphragm pressure causes it to open. Sizes from ½-inch up are available, all with diaphragms of ample area to insure complete and dependable throttling action. Write for descriptive circular with table of types and sizes available.

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CATALOGS . . . BULLETINS

Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking

Canning Equipment

Sprague-Sells Corporation, Hoopeston, Illinois, is distributing an interesting illustrated pamphlet "The Ripple That Became a Tidal Wave" which is the story of canned oil and canning machinery.

Steel Flooring

Kerlow Company, Jersey City, New Jersey, is distributing a new bulletin giving technical data on the Kerlow Floor Slab, used for industrial purposes where a solid light weight floor is desired. It is made removable and in any thickness and size desired to conform with requirements.

Meter

The Foxboro Company, Foxboro, Mass., has prepared a new illustrated booklet dealing with its Universal meter for flow, temperature, pressure, of steam, water, air, oil, and gas solutions.

Rotameter

Schutte & Koerting, 12th and Thompson Sts., Philadelphia, is distributing Bulletin 18-R, dealing with the Rotameter for measurement of liquid and gas flow, including technical data covering all types of uses.

Regulators

Chaplin-Fulton Manufacturing Company, 28 Penn Avenue, Pittsburgh, has prepared its 1935 catalog on pressure regulators with automatic cut-off for natural and manufactured gas, and includes the Fulton duplex sensitive gas governor for manufactured gas.

Refrigeration

Carbondale Machine Corporation, Carbondale, Pa., is distributing a technical bulletin on "Capacity and Design Standards for Steam Jet Refrigeration" by C. F. Hende. Request Bulletin W-207-E17.

Refrigeration

Frick Company, Waynesboro, Pa., in Bulletin No. 530 A., "Ice and Frost" describes various types and applicaton of riefrigeration equipment.

Motors

The Louis Allis Company, Milwaukee, has issued the following bulletins: No. 507, describing the line of direct current motors, No. 510, describing totally enclosed fan cooled motors and No. 514, describing single phase capacitator motors.

Stainless Steel

Republic Steel Corporation, Massillon, Ohio, has published an interesting, illustrated booklet on its line of 18-8 stainless steels. Included is a table showing the degree of corrosion-resistance exerted. Request Bulletin No. 125-A.

Transformer

General Electric Company, Schenectady, N. Y., has issued Bulletin GEA-897E, dealing with its air-cooled transformers for lighting and power service. Includes illustrations and engineering information.

Machinery

Worthington Pump and Machinery Corporation, Harrison, N. J., has issued the bulletins: No. W, 110-B2 on Worthington "Horizontal Piston Pattern Pumps for Petroleum Refineries"; No. W-311-B1B—"Worthington Single Stage Volute, Type R, Centrifugal Pumps"; No. S-500-B6D, on "Worthington Vertical Four cycle, direct injection, Type B, C, D, E,—Diesel Engines"; and No. L-400-B5, on "Worthington Multi-V Drives."

Stainless Steel

Crucible Steel Company, Chrysler Building, New York, has issued Section 3 of its catalog, 82 pages on "Corrosion and Heat-Resisting Steels," giving unusually extensive data on all types, and much engineering information, typical installations, machining and fabricating data.

Sheet Iron

Republic Steel Corporation, Massillon, Ohio, is distributing an eight-page folder, "Thumbs Down on Rust," giving reasons for high rust resistance of Toncan copper-molybdenum iron and includes illustrations of typical installations of sheet iron.

Refractories

Plibrico Jointless Firebrick Company, 1800 Kingsbury Street, Chicago, has prepared a 32-page general catalog covering jointless firebrick and other refractory products. Generously illustrated.

Strainer

H. A. Brassert & Company, 310 South Michigan Avenue, Chicago, is distributing a two-page bulletin describing its automatic strainer which continuously and automatically removes suspended solids from liquids.

Pumps

Taber Pump Company, 288 Elm Street, Buffalo, N. Y., is distributing a four-page bulletin describing its line of close-coupled pumps, including interesting data relative advantages of these types of pumps, and traces history of development since 1914.

Testing

Sperry Products, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y., has published an engineering and technical bulletin dealing with the Speery Cammen Adher-O-Scope "Correlation Service Performance, Laboratory Tests and the Adher-O-Scope."

Motors

Harnischfeger Corporation, West National Avenue, Milwaukee, has issued a new bulletin giving details of construction and operation of its line of convertible P & H motors ranging from ½ horsepower, 600 R.P.M. to 125 horsepower, 3600 R.P.M. Request Bulletin H.M. 1.

Regulators

Bailey Meter Company, Cleveland, Ohio, has prepared for distribution a 16-page bulletin on Bailey Feed Water Regulators, listing distinctive features, and diagrammatically illustrates the operation principles. Includes both tight seating and sleeve type construction.

Swivel Joints

Barco Manufacturing Company, 1801 Winnemac Avenue, Chicago, in Catalog 254, illustrates a number of applications of swivel joints. They provide 360 degree swivel movements with no tendency to bind and do not leak under alternate steam and cold water and are equally fluid-tight under suction or pressure.

Ammonia

Mathieson Alkali Works, 250 Park Avenue, New York, has prepared a linen wall chart for ammonia users on safe and efficient use of ammonia, outlining safety practices in handling cylinders and emergency measures in case of ammonia leaks. Includes curve showing ammonia pressure-temperature relations.

Insulation

A. P. Green Fire Brick Company, Mexico, Mo., in a current leaflet presents its G-25 controlled insulating fire brick, outlining its advantages and showing graphs of performance. Its use in heating furnaces is fully covered.

Valves

Edward Valve & Manufacturing Company, East Chicago, has issued Bulletin No. 11-G4 describing its forged steel specialties, including gage valves, straight-through valves, strainers, relief valves, special valves for turbine oil lines and small forged steel stop-check valves.

Safety

Linde Air Products Company, New York, has issued two bulletins devoted to safe practice in the use of its products. One contains recommended practices for gas cutting of structural steel and the other precautions and safe practices in the storage, care and handling of oxyacetylene welding and cutting equipment.

Machinery

Worthington Pump and Machinery Corporation, Harrison, N. J., has issued the following bulletins: Worthington Steam Booster Compressors; Worthington Vertical Vacuum Pumps, single- and two-stage; Worthington vertical, four-cycle gas engines, Worthington single-stage volute centrifugal pumps, Worthington Monobloc two-stage centrifugal pumps, Worthington single-stage volute centrifugal pumps, Type L.

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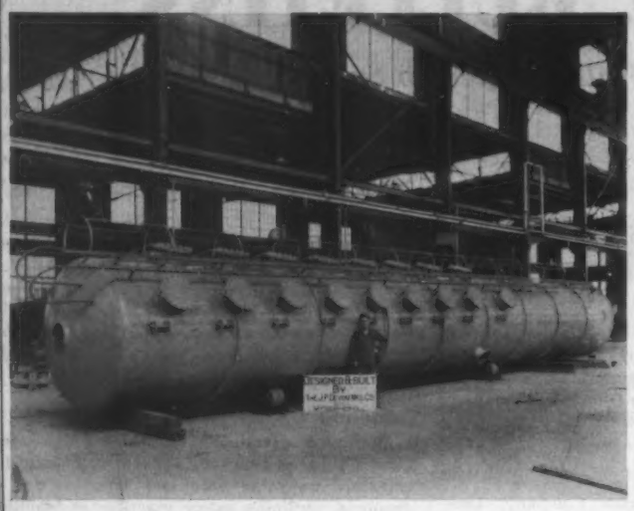

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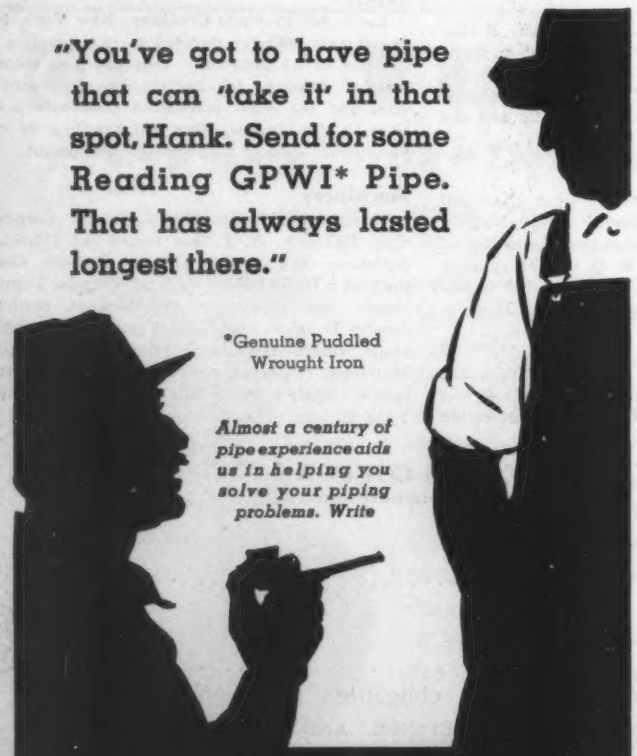

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Advertisers' Index

Alco Products, Inc. 27a
American Brass Company 28a
American Meter Company 26a
American Sand-Banum Company 67a
Armstrong Machine Works 18a

The Bristol Company 30a
The Brown Instrument Company 24a

The Chaplin-Fulton Manufacturing Company 68a
Chapman Valve Manufacturing Company 41a
Chicago Bridge & Iron Works 61a
Cooper-Bessemer Corporation .....
Cork Insulation Company 44a
Crucible Steel Company 33a

DeLaval Steam Turbine Company 23a
J. P. Devine Manufacturing Company 70a
E. I. DuPont de Nemours & Company 13a
The Duriron Company 57a

The Eagle-Picher Lead Company 21a
Elliott Company 25a

Fisher Governor Company 53a
Fluor Corporation 62a
Foster Wheeler Corporation 29a
The Foxboro Company 16a

The Garlock Packing Company 65a
Gasoline Products Company 55a
General Electric Company 7a
Goodyear Tire & Rubber Company 6a
Goulds Pumps, Inc. 19a
Gulf Publishing Company 45a

Haden Lime Company 53a
Illinois Steel Company 12a
Ingersoll-Rand Company 31a

Jerguson Gage & Valve Company 32a
Johns-Manville Corporation 15a

The M. W. Kellogg Company 22a
Kerlow Steel Flooring Company 32a
Walter Kidde & Company 47a
Kieley & Mueller, Inc. 50a
Kinney Manufacturing Company 46a

The LaBour Company 66a
The Lagonda Manumacturing Company 58a
Landis Machine Company 4a
Leeds & Northrup Company 34a
Liberty Manufacturing Company .....
The Lummus Company 20a

Mason-Neilan Regulator Company 5
A. Y. McDonald Manufacturing Company Back Cover
Merco Nordstrom Valve Company ..... Third Cover
The Marley Company 8a

National Tube Company 38a
Newark Wire Cloth Company 32a
W. H. Nicholson & Company 54a

Oakite Products, Inc. 67a

Pittsburgh Steel Company 17a
Pulmosan Safety Equipment Company 67a
Quimby Pump Company 56a

Reading Iron Company 70a
Reading, Pratt & Cady Company 35a
Republic Steel Corporation ..... 36a and 43a
The Ridge Tool Company 30a
The Roto Company 56a

Sarco Company 64a
Hugo Schuhle 67a
Shand & Jurs Company 49a
Southern Alkali Company 59a
Sun Shipbuilding & Dry Dock Company 10a

C. J. Tagliabue Manufacturing Company 11a
Taylor Instrument Companies 14a
The Toledo Pipe Threading Machine Company 60a
Troy Engine & Machine Company 62a

Universal Oil Products Company 37a

Henry Vogt Machine Company ..... Second Cover

Webster Engineering Company ..... Front Cover
Williams, Brown & Earle, Inc. 67a

York Ice Machinery Corporation 51a